Meeting of the Central Valley Flood Protection Board
September 23, 2010

Staff Report

California Department of Fish and Game
Merced River Ranch Fish Restoration Project, Fresno County

1.0 – ITEM

Consider approval of Permit No. 18622 (Attachment B)

2.0 – APPLICANT

California Department of Fish and Game (DFG)

3.0 – LOCATION

The project is located northeast of the City of Merced, south of Merced Falls Road, west of McSwain Dam, and east of Snelling in the Fresno County.
(Merced River, Fresno County, see Attachment A)

4.0 – DESCRIPTION

Applicant proposes to rehabilitate and enhance productive juvenile salmonid rearing habitat by excavating, filling, re-grading, and processing approximately 56,000 cubic yards of material within the Merced River Designated Floodway; which will widen portions of the channel by removing material from the channel, process and separate the material, and place suitable material in a manner within the floodway and channel to obtain the topography and material required to reestablish channel and floodplain habitat connectivity, along approximately 4,650-linear-feet of the Merced River.

5.0 – PROJECT ANALYSIS

Detailed project information is shown below in Sections 5.1 to 5.6. For additional information see Attachments D, E, and F for the Hydraulic Profile, Project Design, and the Restoration Mitigation and Monitoring Programs for the proposed project, respectively.

5.1 – Project Background

In 1998, the California Department of Fish and Game (CDFG) acquired the Merced River Ranch (MRR) with the goals of protecting riparian habitat, improving conditions for salmonids, and supporting some public access. Restoration planning began with Phase I of the Merced River Corridor Restoration Plan, funded by U.S. Fish and Wildlife Service's Anadromous Fish Restoration Program (AFRP). The Merced River Stakeholders (MRS) and Technical Advisory Committee (TAC) were established during Phase I planning, and tasked with providing input throughout the duration of the project. The primary goal of Phase I was to provide a technically-sound, publicly-supported and feasible plan to restore habitat for fish populations in the lower 52 mi (84 km) of the Merced River. The plan extent is from Crocker-Huffman Dam to the confluence with the San Joaquin River, and includes the Dredger Tailings Reach (DTR) in which MRR is contained.

Phase II of the process was funded by CALFED in 1998, and consisted of baseline investigations into the geomorphic and riparian vegetation characteristics of the project reach. These investigations include the DTR and also identify social, institutional, and infrastructural opportunities and constraints for restoration. In 2000, CALFED funded Phase III that included the development of the Merced River Corridor Restoration Plan and a series of public workshops to present the plan and receive input from MRS, TAC, and the public.

From 2003-2006, Phase IV of the planning process built upon the Phase III plan with funding from the California Bay-Delta Authority (CBDA). The Phase IV objective was to design pilot floodplain and channel restoration experiments at MRR to initiate the restoration of natural ecosystem function, and to develop monitoring and evaluation plans to improve scientific understanding of the driving processes for floodplain restoration and inform future projects.

In Phase V of this work the project plan will be reviewed, revised, permitted, and implemented, building on the work of the previous phases. All actions will be carefully monitored to document implementation results, the effectiveness of the project at providing habitat for salmonids, and to validate the core assumptions of the project through controlled experiments.

All monitoring will be focused to address the goals of AFRP and to inform similar projects elsewhere in the Central Valley. Similar work has occurred successfully on the Mokelumne River. Project objectives included providing additional salmonid spawning gravels (~1,400 yds^3 annually; ~1,940 tons), and improving inter-gravel water quality. The study showed that rehabilitated sites produce 30-35% more fry than pre-existing degraded sites. Collaborative monitoring studies also showed that improving spawning habitat improves conditions for other salmon life stages, as well as benthic macroinvertebrate production. Juvenile fish were found foraging in the side channel in densities of up to 2.71 fish m2. Wheaton et al. designed and monitored gravel placements using an integrated approach that assessed the status of salmonid spawning physical habitat conditions as an indicator of ecosystem health. Through restoration monitoring, these projects demonstrated the value of habitat restoration to native salmon populations. Although few studies have established relationships between the ability of habitat to produce salmon on a watershed scale and easily measurable habitat variables, restoration projects provide an opportunity to explore those links. Post-project monitoring developed as part of this project will draw on previous studies to evaluate the physical and biological parameters of ecosystem health, development, and productivity, in terms of juvenile rearing, egg-to-fry survival, and river ecosystem rehabilitation (Attachment F).

5.2 – Project Design Review

Board staff has reviewed the following documents, provided by the applicant, in preparation of this staff report:

- Merced River Ranch Hydraulic Analysis Memorandum
- Merced River Ranch Restoration Project Plans
- Merced River Ranch Mitigation and Monitoring Program

5.3 – Hydraulic Analysis

The proposed project was analyzed using the one-dimensional HEC-RAS 4.0 model. A 100-year event was used for analysis, which represented a flow of 14,900-cfs. The flows represented by the 100-year event is an extreme flood condition, as the largest flows on record for Crocker-Huffman Dam gage data is approximately 8,279-cfs (recorded in 1997). The analysis utilized composite manning’s roughness coefficients of 0.045 for existing and 0.037 for proposed in-channel values. For non-channel surfaces roughness coefficients ranging from 0.05 to 0.1 were used to represent the existing and proposed side channel, floodplain, channel margins, and vegetated tailings.

The proposed project condition actually improves the hydraulic function and passing of flood flows within the project area. There is an overall change in water surface elevation (WSE) from 0 to -0.7-feet, which yields an average decrease in WSE of 0.25-feet over the project area. This decrease is due to a widening of the floodway to more functionally use a low flow channel, which in-turn will provide a suitable habitat for salmonids. Therefore, after staff review, it has been determined that the hydraulic impacts for this project are negligible and the design is in accordance with current standards. See Attachment D for Hydraulic Profile and Tabular Data information.

5.4 – Geotechnical Analysis

Upon completion of staff review of the design plans, staff is in agreement with the conclusion that this project does not bear any significant geotechnical impacts on the designated floodway and all work to be completed will be done in a manner that does not pose a threat to the structural integrity of the channel or floodway. All earthwork shall be completed in compliance with Permit No. 18622 (Attachment B) and Title 23 Standards.

5.5 – Project Benefits

The project has the following benefits associated with its completion:

- Balance sediment supply and transport capacity to allow the accumulation and retention of salmonid spawning gravel;
- Restore floodplain functions that foster recruitment of riparian vegetation and the quality of riparian habitat;
- Increase in-channel habitat complexity to improve aquatic habitat for native aquatic species; and
- Re-engineer the low-flow and bank-full channel geometry so that it is scaled to function properly under current (regulated) flow conditions and to prevent riparian vegetation encroachment in the active channel.

5.6 – Additional Staff Analysis

This project does not include (as reflected in Draft Permit No. 18622 – Attachment B) any vegetative plantings within the floodway. This, however, does not preclude seeding any exposed slopes with native grasses for slope stability. Any vegetation to be planted within the floodway will require a separate permit.

6.0 – AGENCY COMMENTS AND ENDORSEMENTS

The comments and endorsements associated with this project, from all pertinent agencies are shown below:

- A U.S. Army Corps of Engineers (Corps) Non-Fed letter was received July 23, 2010 (Attachment C) stating that the project does not affect a federally constructed project and that they have no comments about the project at this time.

7.0 – CEQA ANALYSIS

Board staff has prepared the following CEQA Findings:

The Board, as a responsible agency under CEQA, has reviewed the Initial Study/ Mitigated Negative Declaration (IS/MND) (SCH No. 2010041098, April 2010) and Mitigation Monitoring and Reporting Program for the Merced River Ranch Floodplain Restoration Project, prepared by the lead agency, the California Department of Fish and Game (CDFG). These documents, including project design, may be viewed or downloaded from the Central Valley Flood Protection Board website at http://www.cvfpb.ca.gov/meetings/2010/9-23-2010agenda.cfm under a link for this agenda item. The documents are also available for review in hard copy at the Board office and the CDFG Regional Office, 1234 E. Shaw Avenue, Fresno, CA 93710.

The California Department of Fish and Game determined that the project would not have a significant effect on the environment and filed a Notice of Determination was filed with the State Clearinghouse on June 28, 2010. Board staff finds that although the proposed project could have a potentially significant effect on the environment, there will not be a significant effect in this case because revisions in the project have been made by or agreed to by the project proponent. The project proponent has incorporated mandatory mitigation measures into the project plans to avoid identified impacts or to mitigate such impacts to a point where no significant impacts will occur. These mitigation measures are included in the project proponent's Mitigation Monitoring and Reporting Program and address impacts to biological resources, hydrology and water quality. The description of the mitigation measures are further described in the adopted Mitigation Monitoring and Reporting Program.

8.0 – SECTION 8610.5 CONSIDERATIONS

1. Evidence that the Board admits into its record from any party, State or local public agency, or nongovernmental organization with expertise in flood or flood plain management:

   The Board will make its decision based on the evidence in the permit application and attachments, this staff report, and any other evidence presented by any individual or group.

2. The best available science that related to the scientific issues presented by the executive officer, legal counsel, the Department or other parties that raise credible scientific issues.

   The accepted industry standards for the work proposed under this permit as regulated by Title 23 have been applied to the review of this permit.

3. Effects of the decision on the entire State Plan of Flood Control:

   This project does not have significant impacts on the State Plan of Flood Control, as the project does not impair the structural or hydraulic functions of the system.

4. Effects of reasonable projected future events, including, but not limited to, changes in hydrology, climate, and development within the applicable watershed:

   Climate change issues have not been taken into account; however, it is assumed to be inland past the point tidal influence raises WSE. There are no other foreseeable projected future events that would impact this project.

9.0 – STAFF RECOMMENDATION

Staff recommends that the Board adopt the CEQA findings, approve Permit No. 18622, and direct staff to file a Notice of Determination with the State Clearinghouse.

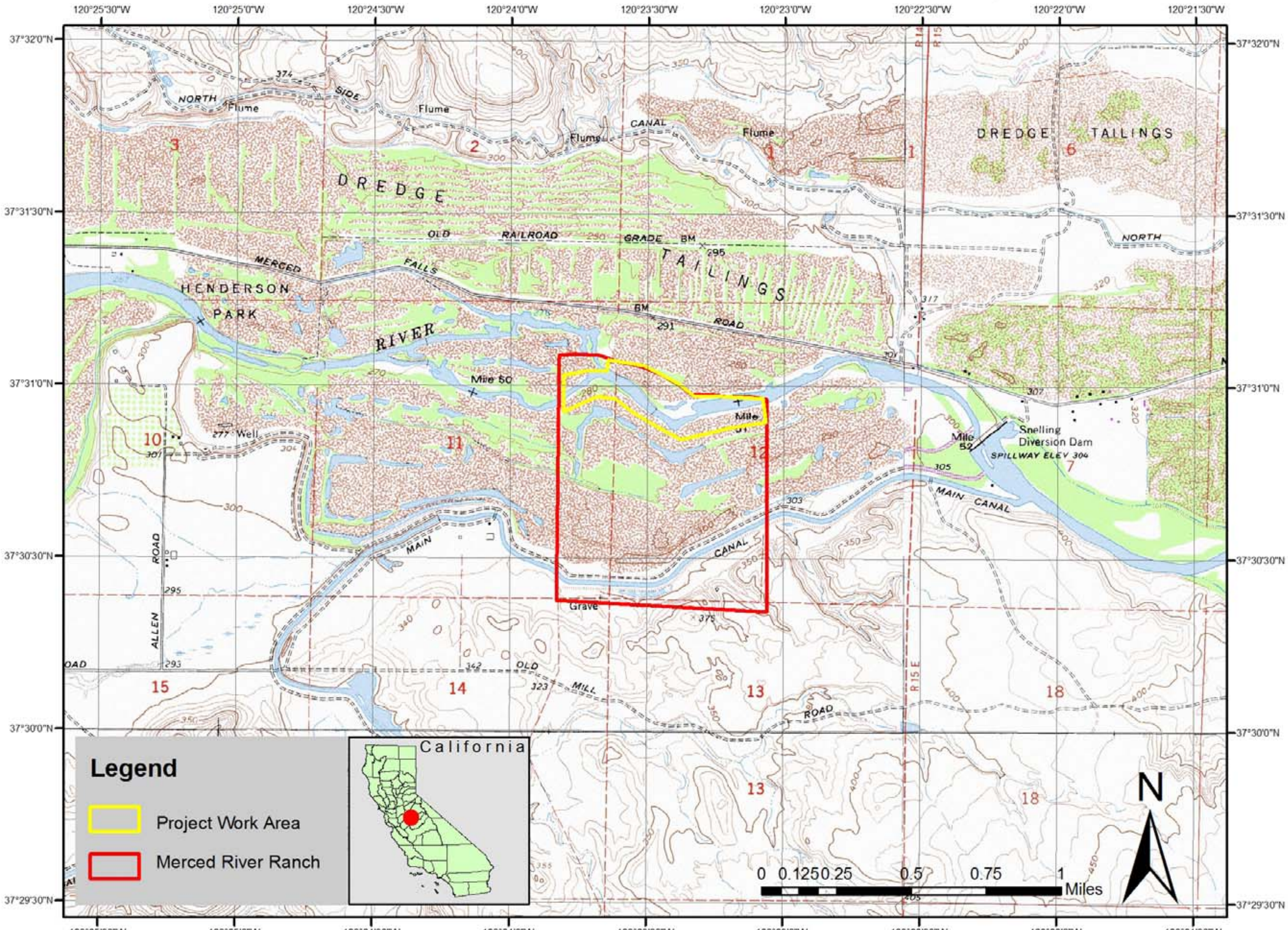
10.0 – LIST OF ATTACHMENTS

A. Location Maps and Photos
B. Draft Permit No. 18622
C. Corps Non-Fed letter
D. Hydraulic Profile and Tabular Data

E. Overall Plan and Typical Cross Sections and Details
F. Restoration Mitigation and Monitoring Program

Design Review:	Nancy C. Moricz, P.E.
Environmental Review:	Andrea Mauro, E.S.
	James Herota, E.S.
Document Review:	David R. Williams, P.E. – Senior Engineer
	Dan S. Fua, P.E. – Supervising Engineer
	Len Marino, P.E. – Chief Engineer

Merced River Ranch Floodplain Restoration Project



ATTACHMENT A - Location Map and Photos

Merced River Ranch View 1: South side of river looking northwest, dredger tailings are prominent feature of landscape and interrupt floodplain function.

Merced River Ranch View 2: South side of river looking north, side channel connection will be established in this area and floodplain excavation will occur on far side. Note, background dredger tailings are prominent feature of landscape and interrupt floodplain function.

DRAFT

STATE OF CALIFORNIA
THE RESOURCES AGENCY

THE CENTRAL VALLEY FLOOD PROTECTION BOARD

PERMIT NO. 18622 BD

This Permit is issued to:

California Department of Fish and Game
1234 E. Shaw Avenue
Fresno, California 93710

To rehabilitate and enhance productive juvenile salmonid rearing habitat by excavating, filling, re-grading, and processing approximately 56,000 cubic yards of material within the Merced River Designated Floodway; which will widen portions of the channel by removing material from the channel, process and separate the material, and place suitable material in a manner within the floodway and channel to obtain the topography and material required to reestablish channel and floodplain habitat connectivity, along approximately 4,650-linear-feet of the Merced River. The project is located east of Snelling and south of Merced Falls Road (Section 11&12, T5S, R14E, MDB&M, Merced River, Fresno County).

NOTE: Special Conditions have been incorporated herein which may place limitations on and/or require modification of your proposed project as described above.

(SEAL)

Dated: ______________________ ______________________
Executive Officer

GENERAL CONDITIONS:

ONE: This permit is issued under the provisions of Sections 8700 – 8723 of the Water Code.

TWO: Only work described in the subject application is authorized hereby.

THREE: This permit does not grant a right to use or construct works on land owned by the Sacramento and San Joaquin Drainage District or on any other land.

FOUR: The approved work shall be accomplished under the direction and supervision of the State Department of Water Resources, and the permittee shall conform to all requirements of the Department and The Central Valley Flood Protection Board.

FIVE: Unless the work herein contemplated shall have been commenced within one year after issuance of this permit, the Board reserves the right to change any conditions in this permit as may be consistent with current flood control standards and policies of The Central Valley Flood Protection Board.

SIX: This permit shall remain in effect until revoked. In the event any conditions in this permit are not complied with, it may be revoked on 15 days' notice.

SEVEN: It is understood and agreed to by the permittee that the start of any work under this permit shall constitute an acceptance of the conditions in this permit and an agreement to perform work in accordance therewith.

EIGHT: This permit does not establish any precedent with respect to any other application received by The Central Valley Flood Protection Board.

NINE: The permittee shall, when required by law, secure the written order or consent from all other public agencies having jurisdiction.

TEN: The permittee is responsible for all personal liability and property damage which may arise out of failure on the permittee's part to perform the obligations under this permit. If any claim of liability is made against the State of California, or any departments thereof, the United States of America, a local district or other maintaining agencies and the officers, agents or employees thereof, the permittee shall defend and shall hold each of them harmless from each claim.

ELEVEN: The permittee shall exercise reasonable care to operate and maintain any work authorized herein to preclude injury to or damage to any works necessary to any plan of flood control adopted by the Board or the Legislature, or interfere with the successful execution, functioning or operation of any plan of flood control adopted by the Board or the Legislature.

TWELVE: Should any of the work not conform to the conditions of this permit, the permittee, upon order of The Central Valley Flood Protection Board, shall in the manner prescribed by the Board be responsible for the cost and expense to remove, alter, relocate, or reconstruct all or any part of the work herein approved.

SPECIAL CONDITIONS FOR PERMIT NO. 18622 BD

THIRTEEN: All work approved by this permit shall be in accordance with the submitted drawings and specifications except as modified by special permit conditions herein. No further work, other than that approved by this permit, shall be done in the area without prior approval of the Central Valley Flood Protection Board.

FOURTEEN: There shall be no plantings withing the project area under this permit, except that of native grasses, which may be required for slope protection. The permittee shall be required to apply for a separate or modified permit for any proposed plantings within the floodway.

FIFTEEN: The permittee is responsible for all liability associated with construction, operation, and maintenance of the permitted facilities and shall defend, indemnify, and hold the Central Valley Flood Protection Board and the State of California; including its agencies, departments, boards, commissions, and their respective officers, agents, employees, successors and assigns (collectively, the "State"), safe and harmless, of and from all claims and damages arising from the project undertaken pursuant to this permit, all to the extent allowed by law. The State expressly reserves the right to supplement or take over its defense, in its sole discretion

SIXTEEN: The permittee shall defend, indemnify, and hold the Central Valley Flood Protection Board and the State of California, including its agencies, departments, boards, commissions, and their respective officers, agents, employees, successors and assigns (collectively, the "State"), safe and harmless, of and from all claims and damages related to the Central Valley Flood Protection Board's approval of this permit, including but not limited to claims filed pursuant to the California Environmental Quality Act. The State expressly reserves the right to supplement or take over its defense, in its sole discretion.

SEVENTEEN: The Central Valley Flood Protection Board and Department of Water Resources shall not be held liable for damages to the permitted project resulting from releases of water from reservoirs, flood fight, operation, maintenance, inspection, or emergency repair.

EIGHTEEN: The permittee shall be responsible for repair of any damages to the floodway or any other flood control facilities due to construction, operation, or maintenance of the proposed project.

NINETEEN: The permittee shall provide supervision and inspection services acceptable to the Central Valley Flood Protection Board.

TWENTY: Prior to commencement of excavation, the permittee shall create a photo record, including associated descriptions of existing floodway conditions. The photo record shall be submitted to the Central Valley Flood Protection Board within 30 days of beginning the project.

TWENTY-ONE: No construction work of any kind shall be done during the flood season from November 1 to April 15 without prior approval of the Central Valley Flood Protection Board.

TWENTY-TWO: The permittee shall contact the Department of Water Resources by telephone, (916) 574-0609, and submit the enclosed postcard to schedule a preconstruction conference. Failure to do so at least 10 working days prior to start of work may result in delay of the project.

TWENTY-THREE: Temporary staging, formwork, stockpiled material, equipment, and temporary buildings shall not remain in the floodway during the flood season from November 1 to April 15.

TWENTY-FOUR: Debris that may accumulate within the permitted project area shall be cleared off and disposed of outside the floodway after each period of high water.

TWENTY-FIVE: After each period of high water, debris that accumulates at the site shall be completely removed from the floodway.

TWENTY-SIX: Any vegetative material, living or dead, that interferes with the successful execution, functioning, maintenance, or operation of the adopted plan of flood control must be removed by the permittee at permittee's expense upon request by the Central Valley Flood Protection Board or Department of Water Resources. If the permittee does not remove such vegetation or trees upon request, the Central Valley Flood Protection Board reserves the right to remove such at the permittee's expense.

TWENTY-SEVEN: Cleared trees and brush shall be completely burned or removed from the floodway, and downed trees or brush shall not remain in the floodway during the flood season from November 1 to April 15.

TWENTY-EIGHT: Fill material shall be placed only within the area indicated on the approved plans.

TWENTY-NINE: Backfill material for excavations shall be placed in 4- to 6-inch layers and compacted to at least the density of the adjacent, firm, undisturbed material.

THIRTY: Density tests by a certified materials laboratory will be required to verify compaction of backfill within the floodway and channel.

THIRTY-ONE: All debris generated by this project shall be disposed of outside the floodway.

THIRTY-TWO: The work area shall be restored to the condition that existed prior to start of work.

THIRTY-THREE: The permittee shall submit as-built drawings to the Department of Water Resources' Flood Project Inspection Section upon completion of the project.

THIRTY-FOUR: The permittee shall maintain the permitted project works within the utilized area in the manner required and as requested by the authorized representative of the Department of Water Resources or any other agency responsible for maintenance.

THIRTY-FIVE: If the permitted project result(s) in an adverse hydraulic impact, the permittee shall provide appropriate mitigation measures, to be approved by the Central Valley Flood Protection Board, prior to implementation of mitigation measures.

THIRTY-SIX: In the event that floodway or bank erosion injurious to the adopted plan of flood control occurs at or adjacent to the permitted project, the permittee shall repair the eroded area and propose measures, to be approved by the Central Valley Flood Protection Board, to prevent further erosion.

THIRTY-SEVEN: The permitted project shall not interfere with operation and maintenance of the flood control project. If the permitted project is determined by any agency responsible for operation or maintenance of the flood control project to interfere, the permittee shall be required, at permittee's cost and expense, to modify or remove the permitted encroachment(s) under direction of the Central Valley Flood Protection Board or Department of Water Resources. If the permittee does not comply, the Central Valley Flood Protection Board may modify or remove the encroachment(s) at the permittee's expense.

THIRTY-EIGHT: The permittee may be required, at permittee's cost and expense, to alter, relocate, or reconstruct all or any part of the permitted project if alteration, relocation, or reconstruction is necessary as part of or in conjunction with any present or future flood control plan or project or if damaged by any cause. If the permittee does not comply, the Central Valley Flood Protection Board may remove the project at the permittee's expense.

THIRTY-NINE: If the project, or any portion thereof, is to be abandoned in the future, the permittee or successor shall abandon the project under direction of the Central Valley Flood Protection Board and Department of Water Resources, at the permittee's or successor's cost and expense.

FORTY: A copy of this permit shall be included as an attachment to any Long-Term Management Plan for the permitted project area.

FORTY-ONE: All conservation easements established within this project area shall be junior to flowage and maintenance easements within the project limits.

FORTY-TWO: The permittee shall be responsible for securing any necessary permits incidental to habitat manipulation and restoration work completed in the flood control project, and will provide any biological surveying, monitoring, and reporting needed to satisfy those permits.

FORTY-THREE: The permittee agrees to incur all costs for compliance with local, State, and Federal permitting and resolve conflicts between any of the terms and conditions that agencies might impose under the laws and regulations it administers and enforces.

FORTY-FOUR: This permit shall run with the land and all conditions are binding on permitee's successors and assigns.

DEPARTMENT OF THE ARMY
U.S. Army Engineer District, Sacramento
Corps of Engineers
1325 J Street
Sacramento, California 95814-2922

REPLY TO
ATTENTION OF

Flood Protection and Navigation Section (18622)

JUL 23 2010

Mr. Jay Punia, Executive Officer
Central Valley Flood Protection Board
3310 El Camino Avenue, Room 151
Sacramento, California 95821

Dear Mr. Punia:

We have reviewed a permit application by the California Department of Fish and Game (application number 18622). This project includes excavating, filling, regrading and processing approximately 56,000 cubic yards of material within the Designated Floodway of the Merced River. The proposed project is located east of Snelling and south of Merced Falls Road, at 37.5149°N 120.3901°W NAD83, Fresno County, California.

The District Engineer has no comments or recommendations regarding flood control because the proposed work does not affect a federally constructed project.

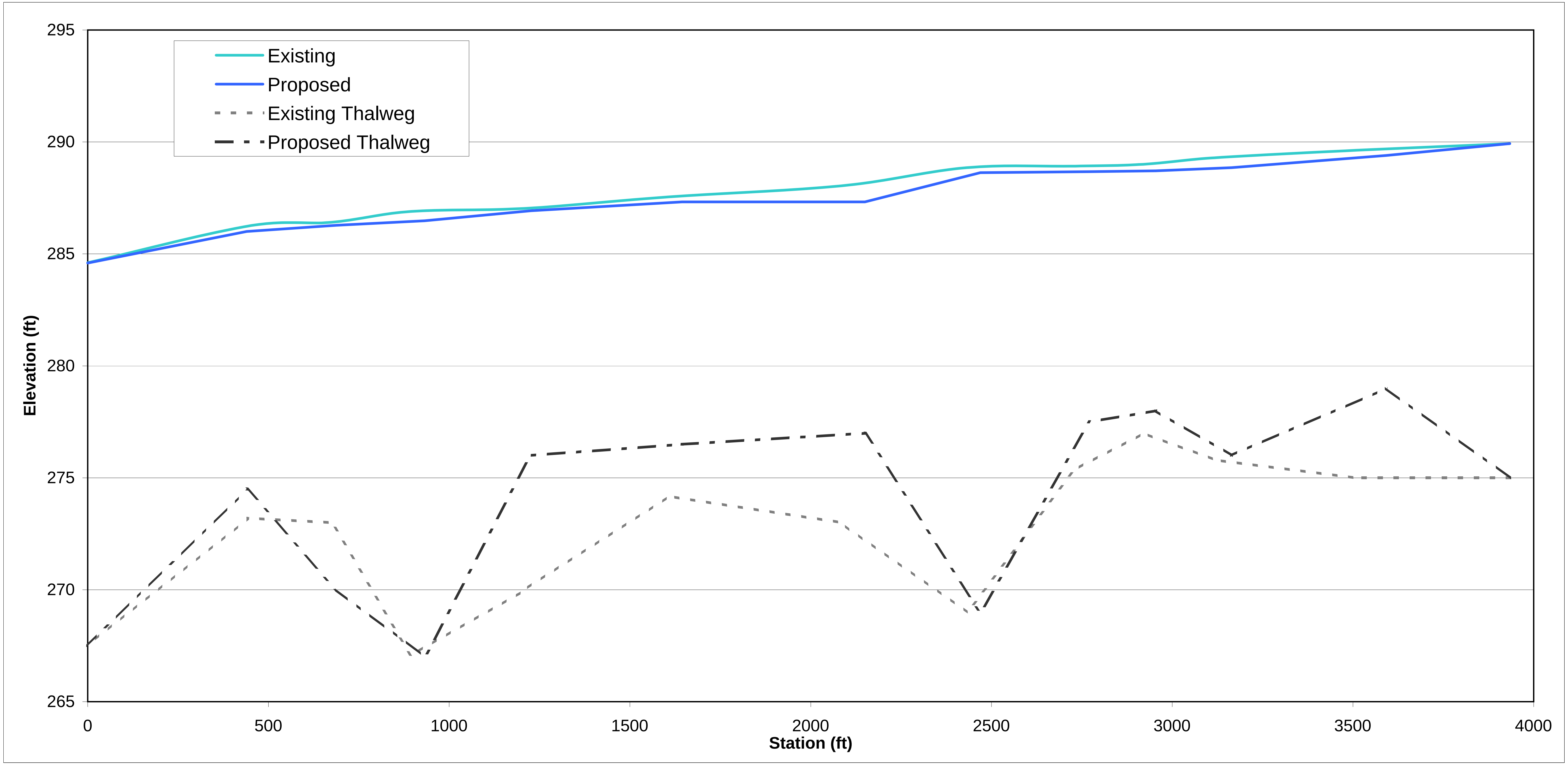
There is not enough information provided to determine if there is a permit action under Section 10 and/or Section 404. Please advise the applicant to contact the U.S. Army Corps of Engineers, Sacramento District, Regulatory Division, 1325 J Street, Sacramento, California 95814, telephone (916) 557-5250.

A copy of this letter is being furnished to the acting chief, Flood Project Integrity and Inspection Branch, 3310 El Camino Avenue, Suite LL30, Sacramento, CA 95821.

Sincerely,

Meegan G. Nagy

Meegan G. Nagy, P.E.
Chief, Flood Protection and Navigation Section



Datum: NGVD29

Notes: Interpolated cross sections not shown.

FIGURE 3

MERCED RIVER RANCH HYDRAULIC MODEL

WATER SURFACE ELEVATION PROFILES FOR EXISTING AND PROPOSED CONDITIONS

PWA Ref #: 1234.00

PWA

ATTACHMENT D - Hydraulic Profile and Tabular Data

Table 1. Modeled Boundary Conditions

Boundary Conditions	Existing	Proposed
Discharge (cfs)	14,900	14,900
Normal Depth Slope (ft/ft)	0.002	0.002

Table 2. Composite In-Channel Roughness Summary for Existing and Proposed Conditions

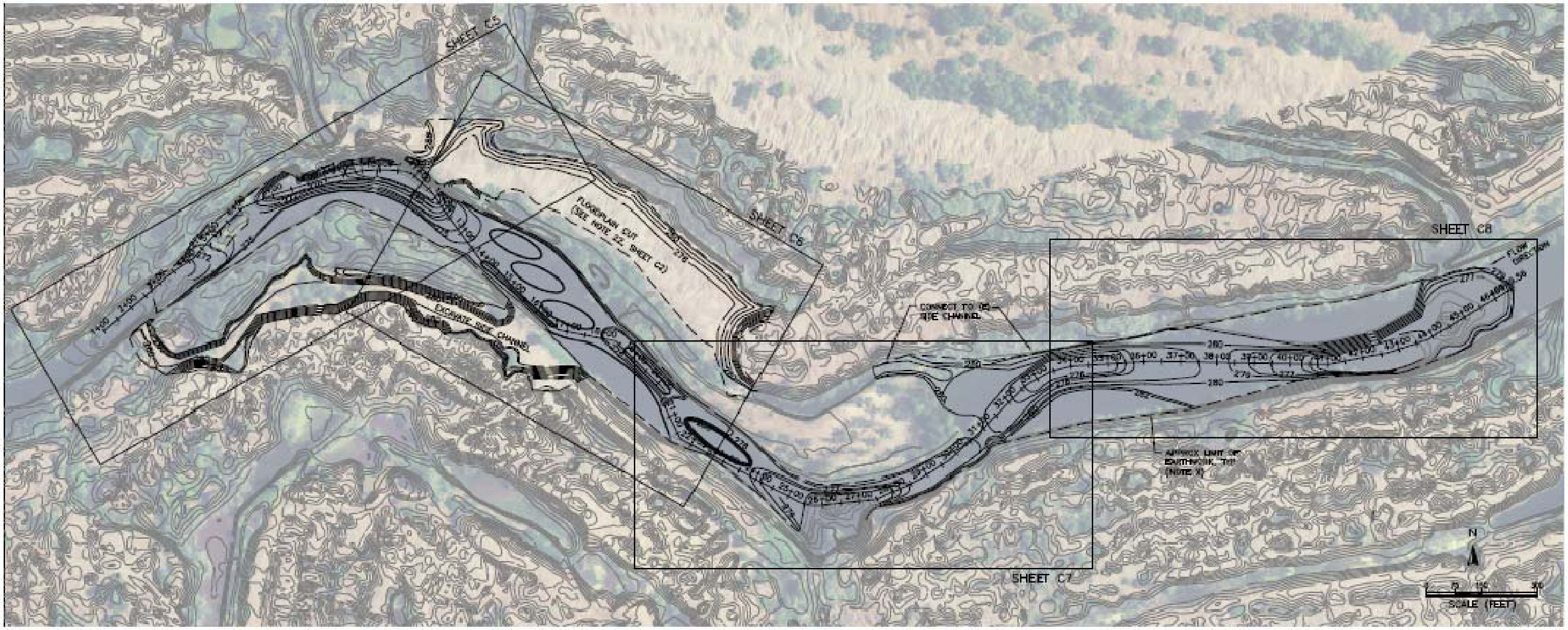
Parameter	Existing Conditions	Proposed Conditions
m, Ratio of channel length to valley length	1	1
n_b, Grain roughness	0.036	0.029
n_1, Surface irregularities	0.001	0.002
n_2, Variation in shape and size	0.001	0.002
n_3, Obstructions	0.002	0.002
n_4, Vegetation and flow conditions	0.005	0.003
n, Composite channel roughness	*0.045*	*0.037*

Table 3. Existing and Proposed Conditions Roughness Values for Non-Channel Surfaces

Surface Type	Roughness Value
Existing and Proposed Vegetated Tailings	0.1
Existing Channel Margins	0.07
Existing Gravel Bars with Thin Trees	0.05
Proposed Side Channels	0.05
Proposed Floodplain	0.05
Proposed Channel Margins	0.05

Table 4. Model-Predicted Change in Water Surface Elevations for Existing and Proposed Conditions (NGVD29, in feet)

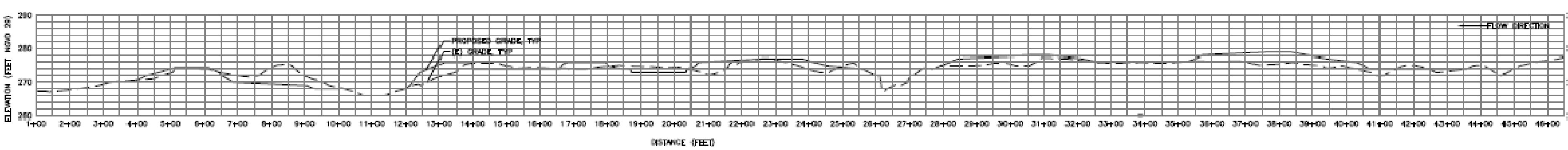
Average Station	Existing	Proposed	Change
3934	289.9	289.9	0
3549.5	289.6	289.4	-0.2
3140.5	289.3	288.9	-0.4
2937.5	289.0	288.7	-0.3
2752	288.9	288.7	-0.3
2450.5	288.9	288.6	-0.2
2117	288.0	287.3	-0.7
1625.5	287.6	287.3	-0.2
1217.5	287.0	286.9	-0.1
913.5	286.9	286.5	-0.4
681	286.4	286.3	-0.1
441.5	286.2	286.0	-0.2
0	284.6	284.6	0.0



PROPOSED GRADING

PLAN VIEW

SCALE: 1"=150'



PROPOSED GRADING

PROFILE

SCALE:
HORIZ. 1"=150'
VERT. 1"=15'

THALWEG BASE LINE SURVEY CONTROL

STATION	NORTHING (ft)	EASTING (ft)	LENGTH (ft)	BEARING
1+00	2010405.7	6591806.21	99.42	N49°48'17"E
1+99.42	2010469.88	6591882.15	213.06	N46°58'50"E
4+12.47	2010615.22	6591837.92	88.88	N38°13'07"E
5+01.34	2010685.04	6591892.9	179.48	N61°47'06"E
6+80.81	2010769.89	6592051.05	145.57	N71°10'24"E
8+26.38	2010816.87	6592188.83	122.24	N77°00'52"E
9+48.63	2010844.34	6592307.95	52.23	N87°25'14"E
10+00.86	2010846.69	6592360.13	35.48	S88°10'59"E
10+36.34	2010845.56	6592395.59	31.65	S84°54'05"E
10+67.99	2010842.76	6592427.11	25.45	S71°58'41"E
10+93.44	2010834.87	6592451.32	73.54	S42°37'50"E
11+66.99	2010780.77	6592501.13	224.81	S36°33'24"E
13+91.80	2010600.18	6592635.03	282.87	S47°36'23"E
16+74.67	2010409.47	6592843.94	162.21	S78°53'28"E
18+36.88	2010378.22	6593003.12	188.52	S44°54'21"E
20+25.40	2010244.69	6593136.2	44.34	S00°38'00"E
20+69.74	2010200.36	6593136.69	96.16	S25°41'11"E
21+65.90	2010113.7	6593178.37	131.3	S61°08'47"E

STATION	NORTHING (ft)	EASTING (ft)	LENGTH (ft)	BEARING
22+97.20	2010050.34	6593293.37	83.54	S62°25'25"E
23+80.74	2010011.67	6593367.42	152.43	S61°58'41"E
25+33.17	2009939.97	6593501.94	33.19	S72°40'53"E
25+66.36	2009930.1	6593533.62	24.19	S89°07'09"E
25+90.55	2009929.72	6593557.82	33.56	N82°59'53"E
26+24.11	2009933.81	6593591.13	123.48	N84°05'47"E
27+47.60	2009946.51	6593713.95	128.93	N64°24'34"E
28+76.53	2010002.21	6593830.24	96.89	N58°39'56"E
29+73.42	2010052.59	6593913.00	292.88	N45°43'57"E
32+66.29	2010057.02	6594122.72	71.12	N59°10'48"E
33+37.41	2010294.52	6594183.15	61.83	N74°19'15"E
33+99.23	2010311.23	6594242.67	218.69	N86°29'46"E
36+17.93	2010324.59	6594460.96	484.93	S88°58'19"E
41+02.86	2010316.89	6594945.81	167.28	N79°55'30"E
42+70.14	2010348.03	6595109.97	111.79	N72°31'03"E
43+81.93	2010381.61	6595216.61	267.63	N68°20'49"E
46+49.56	END			

GENERAL PLAN AND PROFILE SHEET NOTES:

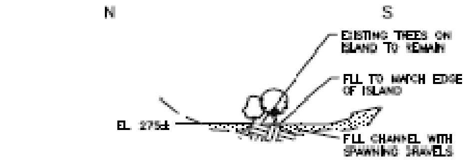
1. THE CHANNEL BASELINE IS BASED ON THE PROPOSED CHANNEL THALWEG (LOW POINT OR FLOW LINE). THE CONTRACTOR SHALL PROVIDE AND MAINTAIN OFFSET STAKES FOR THE CHANNEL BASELINE THROUGHOUT CONSTRUCTION.
2. PROPOSED GRADING CONTOURS ARE SHOWN WITHIN THE LIMITS OF EARTHWORK. FOR CLARITY, EXISTING CONTOURS ARE NOT SHOWN ON SHEETS C4 TO C8.
3. SEE SHEETS C11 THROUGH C14 FOR GRADING SECTIONS SHOWING EXISTING AND DESIGN GRADES. SEE SHEET C3 FOR SECTION LOCATIONS. SEE GRADING SECTIONS FOR EXISTING GRADES.
4. APPROXIMATE LIMITS OF EARTHWORK ARE SHOWN ON THE DRAWINGS. THE ACTUAL LIMITS OF EARTHWORK MAY BE ADJUSTED BY THE OWNER'S REPRESENTATIVE AS THE WORK PROGRESSES BASED ON (A) SITE GRADES AT THE TIME OF CONSTRUCTION, (B) PRESENCE OF VEGETATION TO BE PROTECTED, (C) THE EXACT VOLUME OF GRAVEL NEEDED FOR CHANNEL FILL AND/OR (D) OTHER SITE CONDITIONS.
5. ESTIMATED EARTHWORK QUANTITIES SHOWN ON THE DRAWINGS ARE APPROXIMATE ONLY. QUANTITY ESTIMATES ARE IN-PLACE VOLUMES CALCULATED AS THE DIFFERENCE BETWEEN EXISTING AND PROPOSED CONTOURS USING A DIGITAL TERRAIN MODEL (DTM) AND BEST AVAILABLE SURVEY DATA (SEE SHEET C3 NOTES). THE CONTRACTOR IS RESPONSIBLE FOR PREPARING ALL EARTHWORK VOLUME ESTIMATES AND ITS OWN QUANTITY TAKEOFFS AND SHALL ACCOUNT FOR ADJUSTMENTS TO IN-PLACE VOLUMES INCLUDING, BUT NOT LIMITED TO: BED SETTLEMENT, CONSOLIDATION, COMPACTION, TRANSPORT LOSSES AND SEDIMENT TRANSPORT IN THE ACTIVE CHANNEL.
6. THE CONTRACTOR SHALL PROVIDE SMOOTH GRADING TRANSITIONS AT THE CHANNEL BANKS.

ESTIMATED QUANTITIES (SEE NOTE 5)

Channel Excavation	140,000 Cubic Yards
Channel Fill	60,000 Cubic Yards

PRELIMINARY
NOT FOR CONSTRUCTION

ATTACHMENT E - Overall Plan, Typical X-Sections and Details

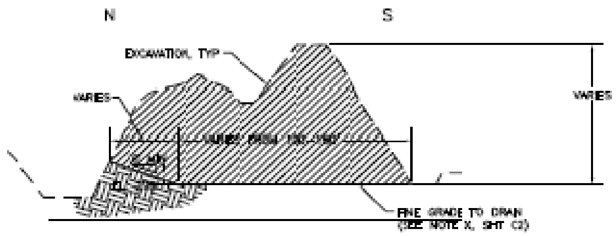


A | C5 | C9

ISLAND FILL AT (E) ISLAND

TYPICAL SECTION N.T.S.

(STA 4+00± TO 6+00)

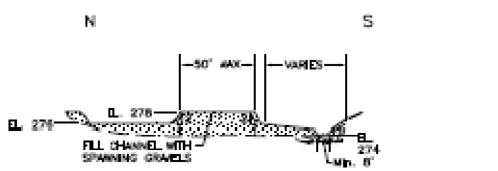


B | C6 | C9

FLOODPLAIN EXCAVATION

TYPICAL SECTION N.T.S.

(STA 10+50± TO 21+00)

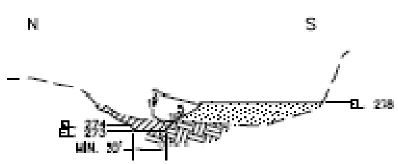


C | C5 | C9

(N) BARS (TYP OF 3)

TYPICAL SECTION N.T.S.

(STA 13+50± TO 17+70±)

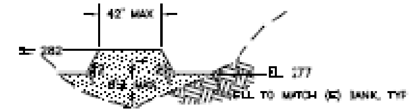


D | - | C9

BAR AND POOL

TYPICAL SECTION N.T.S.

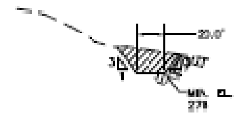
(STA 18+70± TO 20+40±)



E | C8 | C9

CENTRAL BAR RIFFLE

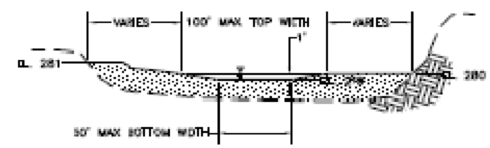
SECTION STA 23+00± N.T.S.



F | C8 | C9

SIDE CHANNEL

SECTION STA 31+00± N.T.S.



G | C8 | C9

RIFFLE

TYPICAL SECTION N.T.S.

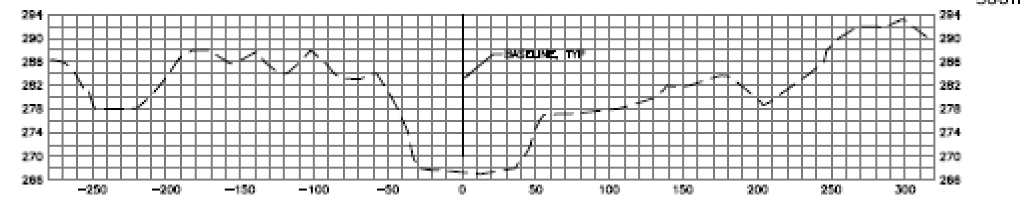
(STA 37+70 TO 38+40±)

ATTACHMENT E - Overall Plan, Typical X-Sections and Details

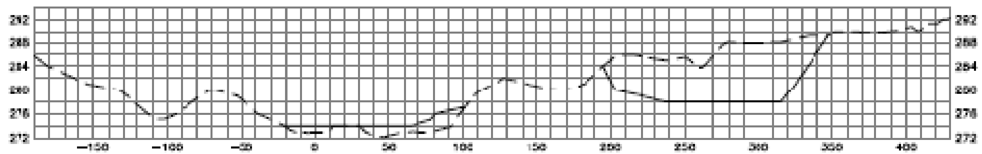
NORTH

1+00

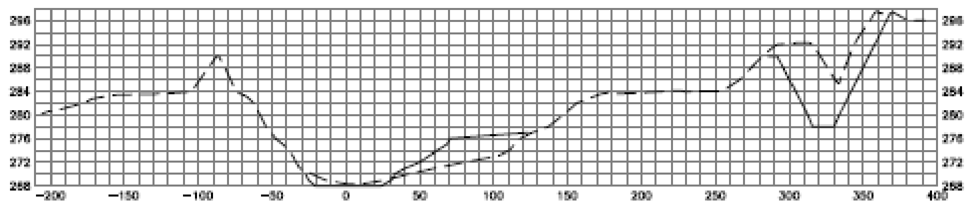
SOUTH



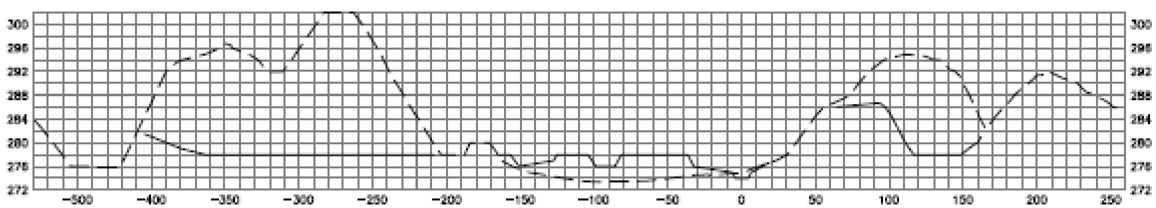
5+00



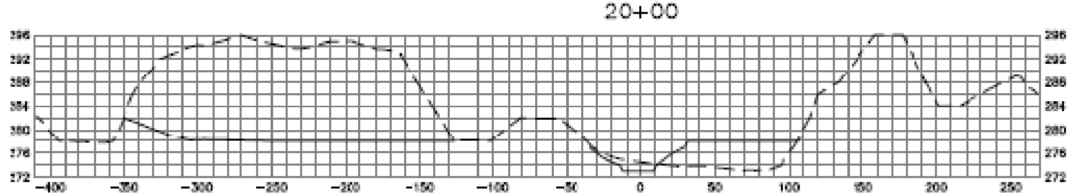
10+00



15+00



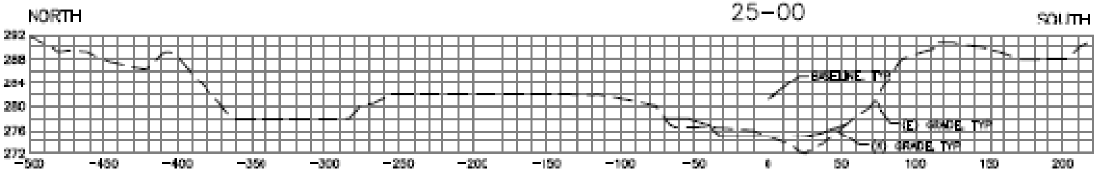
20+00



NORTH

25-00

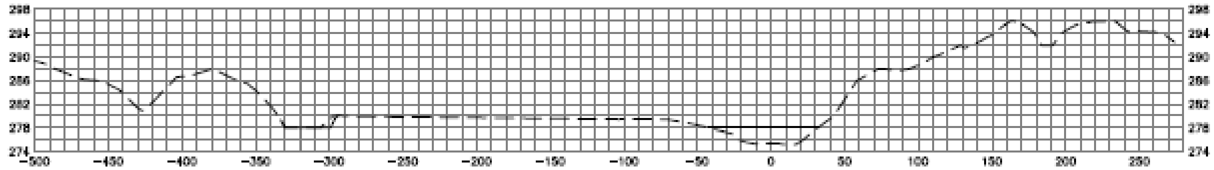
SOUTH



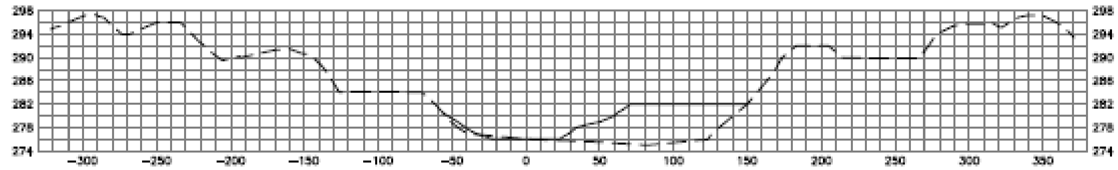
ATTACHMENT E - Overall Plan, Typical X-Sections and Details

ATTACHMENT E - Overall Plan, Typical X-Sections and Details

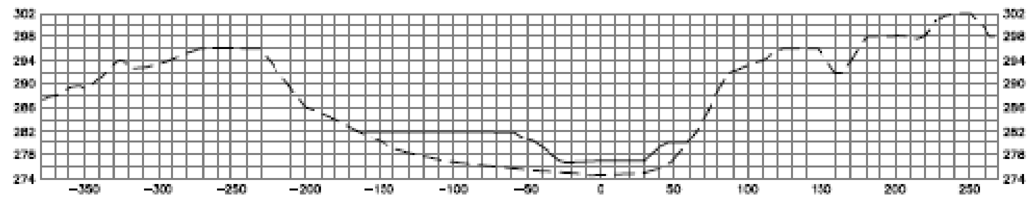
30+00



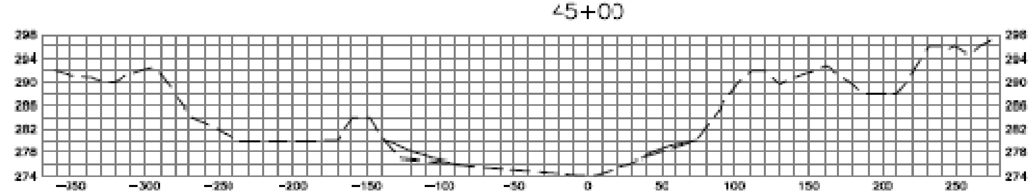
35+00



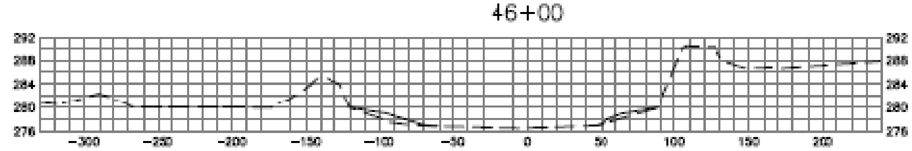
40+00



45+00



46+00



Attachment 1

California Department of Fish and Game – Merced River Ranch Floodplain Restoration Project, Merced River, Merced County, CA

	Mitigation Measure	Implementation Schedule	Responsible Party	Status / Date / Initials
1	Native trees, such as Fremont cottonwood Populus fremontii, oak Quercus spp., and willow Salix spp. with a diameter-at-breast-height (DBH) of 6 in (15.2 cm) or greater will be protected with 30-ft (9.1-m), 10-ft (3-m), and 10-ft (3-m) buffers, respectively. Native trees will be marked with flagging and fenced if close to project work area to prevent disturbance. To compensate for the removal of riparian shrubs and trees during project implementation, the plans would identify tree and shrub species that would be planted, how, where, and when they would be planted, and measures to be taken to ensure a minimum performance criteria of 70% survival of planted trees for a period of three consecutive years. Irrigation will not be used, but the return of inundation to the floodplain is expected to promote growth of native riparian species. If the 70% survival criteria are not met, more native trees will be planted and irrigation will be evaluated. The tree plantings would be based on native tree species compensated for in the following manner: - Oaks having a DBH of 3 – 5 in (7.6 – 12.7 cm) would be replaced in-kind, at a ratio of 3:1, and planted during the winter dormancy period in the nearest suitable location to the area where they were removed. Oaks with a DBH of greater than five inches would be replaced in-kind at a ratio of 5:1. - Riparian trees (i.e., willow, cottonwood, poplar, alder, ash, etc.) and shrubs would be replaced in-kind and on site, at a ratio of 3:1, and planted in the nearest suitable location to the area where they were removed.	Entire Project	Permittee	
2	Following methods in the Stillwater Sciences (2004) Mercury Assessment, total mercury from sediments will be evaluated to insure samples are below or within the range of natural background levels (50–80 ng/g) for California's Central Valley (Bouse et al. 1996). All samples previously collected were below this level (Stillwater Sciences 2004). Aqueous raw total mercury was also found to be below the California Toxics Rule for a drinking water source of 50 ng/L. In-river channel aqueous raw total mercury was at or below levels measured at relative control sites for the Cache Creek watershed (Slotton et al. 2004), a highly mining-impacted watershed in Northern California which has been identified for regulatory and remedial action with regard to mercury (Stillwater Sciences 2004). It is unlikely that excavation and regrading activities may uncover mercury hot spots and or mobilize mercury in the aquatic food web; however, if samples are found with mercury levels above established standards, work will be halted to assess contamination potential. As a further precaution, mercury levels will be measured before, during, and after restoration activities in the MRR area.	During Construction	Permittee	

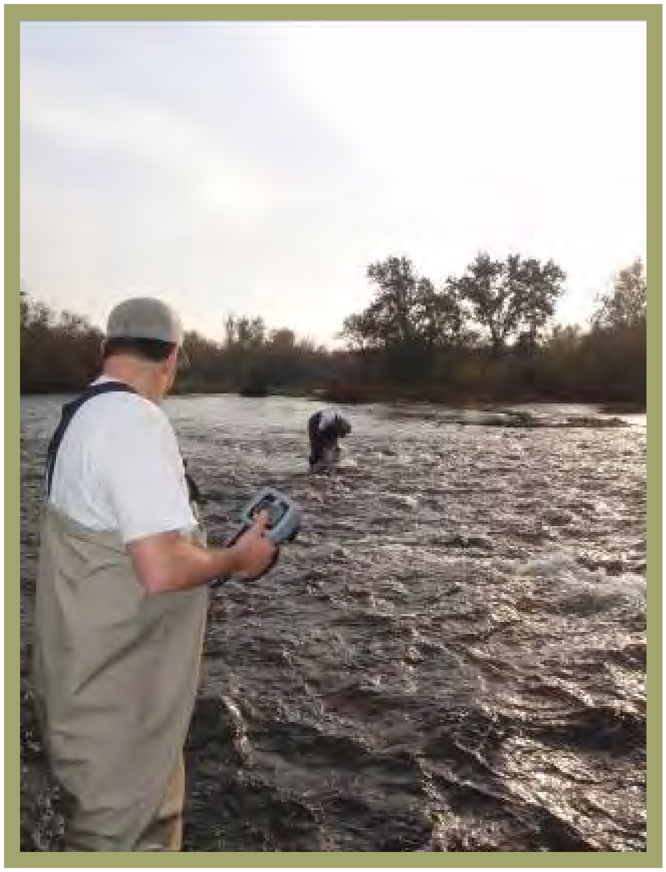
	Mitigation Measure	Implementation Schedule	Responsible Party	Status / Date / Initials
3	To meet CDFG's recommendations for mitigation and protection of Swainson's hawks Buteo swainsoni, surveys will be conducted by a qualified biologist for a ½ mile radius around all project activities. Site surveys will be conducted to identify suitable foraging and roosting habitat and species presence, in accordance with CDFG survey guidelines. The no-disturbance buffer should be a minimum of 0.25 mi (0.40 km) around any identified nests. If State-listed species are found to be nesting in the project area, CDFG will be notified to discuss project implementation and avoidance of take. Note, this project also provides for Swainson's hawk conservation: by restoring the river landscape and ecosystem processes that support riparian forests. Swainson's hawks have strong association with riparian forests which suggests that protection and restoration of these habitats may provide nesting habitat superior to other sources of trees such as roadsides and field margins. Bird species that occupy the mature tree and gallery forest component of riparian systems will also benefit from conservation or restoration of nesting habitat for Swainson's Hawk (Woodbridge 1998).	Entire Project	Permittee	
4	The project will comply with Section 401 of the Clean Water Act and obtain certification for project-related activities to control sediment and maintain water quality downstream of the project site during the construction activities. To minimize risk from additional fine sediments, all trucks and equipment will be cleaned, gravels will be processed away from flowing water, and in-stream work will occur during the low flow season (e.g., < 300 cfs). Sediment fencing will be used along the river corridor to capture floating materials or sediments mobilized during construction activities, and prevent water quality impacts. Stream bank impacts will be isolated and minimized to reduce bank sloughing. The banks will be stabilized with revegetation following project activities.	Entire Project	Permittee	
5	Implement the following dust reduction measures during movement of materials from construction staging area to sites where gravel augmentation will occur to reduce construction-related emissions: □ wet materials to limit visible dust emissions using water; □ provide at least 6 in (15.2 cm) of freeboard space from the top of the container; or, □ cover the container.	During Construction	Permittee/Subcontractors	
6	Implement the following dust reduction measure during gravel placement to reduce construction-related emissions: □ limit or promptly remove any of mud or dirt on construction equipment and vehicles at the end of each workday, or once every 24 hours.	During Construction	Permittee/Subcontractor	
7	Each year, before beginning construction activities a pre-project survey will be conducted of the project site. Extensive surveys for elderberry shrubs have already been completed (URS 2006d), and areas to avoid identified. If elderberry shrubs (or other special status plants) are identified in subsequent surveys they will be avoided. Complete avoidance may be assumed when there is at least a 100-ft (30.5 m) buffer around the plant. These buffers will be established and maintained around all elderberry plants with stems measuring 1 in (2.5 cm) in diameter at the ground level (USFWS 1999). Project activities will be adjusted to ensure no activities occur in the buffer area, thereby avoiding any negative effects on valley elderberry longhorn beetle.	Entire Project	Permittee	

	Mitigation Measure	Implementation Schedule	Responsible Party	Status / Date / Initials
8	Table 5 lists the critical periods when disturbance could result in significant impacts to individuals or populations of special status species. To avoid these impacts, all project ground disturbing activities will be conducted during the period August through September, which is outside the listed critical periods (Table 5 – see EA/IS). If work must be conducted before this time, appropriate surveys would be performed to avoid impacts to special status and sensitive species. Nesting birds and raptors are protected under the MBTA and California Fish and Game Code. Trees and shrubs within the project area likely provide nesting habitat for songbirds and raptors. If tree removal is unavoidable, it will occur during the non-breeding season (mid-September). If other construction activities must occur during the potential breeding season (February through mid-September) surveys for active nests and/or roosts will be conducted by a qualified biologist no more than 30 days prior to the start of construction. A minimum no disturbance buffer will be delineated around active nests (note, size of buffer depends on species encountered) until the breeding season has ended or until a qualified biologist has determined that the birds have fledged and are no longer reliant upon the nest or parental care for survival.	Entire Project	Permittee	
9	For bat species, before any ground disturbing activities, a qualified biologist will survey for the presence of associated habitat types for the bat species of concern. If bats are present, suitable avoidance and conservation measures will be implemented: project will avoid work in May, June, and July and will apply a minimum 300 ft (91.4 m) buffer of roosting bats, maternity roosts or winter hibernacula until all young bats have fledged.	Entire Project	Permittee	
10	Pre-construction surveys will be conducted by qualified wildlife biologists, who will determine the use of the project site by American badgers; surveys will focus on identification of potential badger dens within the construction footprint and a minimum 250 ft (76.2 m) buffer around the construction footprint. If badger dens are located within the construction or buffer area, prior to initiation of construction CDFG will be consulted for further instructions on methods to avoid direct impacts to this species. Pre-construction surveys will also be conducted by qualified wildlife biologists to determine the use of the project site and a minimum 500 ft (152.4 m) buffer around the construction footprint by San Joaquin kit fox; surveys will focus on identification of potential, atypical, active, and natal (USFWS 1999b) kit fox dens. If potential kit fox dens are located within the construction or buffer area, a minimum of five consecutive nights of camera/scent stations and track stations will be placed by the den entrances in order to determine if the den is in use by kit fox. If active or natal dens are confirmed, CDFG and USFWS will be consulted for further instructions on methods to avoid direct impacts to this species as well as the need for incidental take permits.	Entire Project	Permittee	
11	Special transportation routes and work areas will be designated to avoid damaging trees and shrubs in riparian habitats, especially those sensitive species described above. Potential impacts to the riparian vegetation could occur during the transport of gravel from construction staging area to the river. These impacts will be minimized to the greatest extent practicable by selecting routes that avoid or minimize damage. There will be no impacts on heritage size trees (i.e., greater than 16 in [40.6 cm] in diameter). Trees will be flagged and fenced (when near work area) to prevent unintended damage	During Construction	Permittee/Subcontractor	

	Mitigation Measure	Implementation Schedule	Responsible Party	Status / Date / Initials
12	To mitigate noise related impacts, the project will require all contractors to comply with the following conditions: restrict construction activities to time periods when there is the least potential for disturbance; install and maintain sound-reducing equipment and muffled exhaust on all construction equipment; and, optimize the location of processing equipment to be the least disturbance in terms of noise for the local residents.	During Construction	Permittee/Subcontractor	
13	If any objects of cultural significance are unearthed during the construction process, work will be halted until a qualified archeologist can assess the significance of the new find. If human remains are unearthed during the construction process, the project team will comply with the California Health and Safety Code Section 7050.5, which states that no further disturbance shall occur until the County Coroner has investigated the situation following the Public Resource Code Section 5097.98.	During Construction	Permittee	
12	The Designated Biologist shall be on-site daily while construction and/or surface-disturbing activities are taking place to minimize take of the Covered Species, to check for compliance with all mitigation and avoidance measures, to check all exclusion zones to ensure that signs, stakes, and fencing are intact, and that human activities are restricted to outside of these protective zones.	Entire Project	Permittee	

Merced River Ranch

Restoration Monitoring Program



Prepared by:

Cramer Fish Sciences

In Collaboration with:

Anadromous Fish Restoration Program

California Department of Fish and Game

Suggested citation: Cramer Fish Sciences (CFS). 2010. Merced River Ranch Restoration Monitoring Program. Prepared for the USFWS' Anadromous Fish Restoration Program and California Department of Fish and Game. 50 pp.

SUMMARY

The following document is intended to provide a detailed description of the monitoring program associated with the Merced River Ranch Floodplain Restoration Project. In 1998, the California Department of Fish and Game (CDFG) acquired the Merced River Ranch (MRR) with the goals of protecting riparian habitat, improving conditions for salmonids, and supporting public access. The project is funded by the U.S. Fish and Wildlife Service (USFWS) Anadromous Fish Restoration Program (AFRP). After many years of researching and planning for various aspects of the project, a final draft design has been completed and the implementation permitting process has begun as of January 2010. Project actions are expected to rehabilitate floodplain habitat in the lower Merced River below Crocker-Huffman Dam, and conduct detailed implementation, effectiveness, and validation monitoring to collect robust data for assessing project success based on target objectives and parameters, and inform similar habitat restoration efforts in the Central Valley.

The monitoring program consists of three conceptual approaches to monitoring: implementation, effectiveness, and validation. The implementation monitoring will determine if the project was installed according to the design standards. Hydrology, topography/bathymetry, sediment budget and vegetation will be assessed. The central question is: Was the project implemented according to plan? The effectiveness monitoring will determine if the project was effective in recovering habitat conditions suitable to target species. A range of physical and biological traits will be tracked before and after restoration to assess ecosystem function. The central question of effectiveness monitoring is: Was the project effective in meeting its target objectives? The final part of the monitoring program will determine if floodplain restoration projects, like the one at MRR, recover *productive* habitat for salmonids and riparian vegetation. This validation monitoring is intended to validate the underlying assumptions of the restoration work. The central question of validation monitoring is: Are the basic assumptions behind the project conceptual model valid? This monitoring program will collect detailed physical and biological information for evaluation. This evaluation may improve our understanding of restored ecosystem function at the MRR and the potential of side channel and floodplain river restoration projects to contribute to improved salmonid populations.

The following monitoring program has been adapted from the Technical Memorandum #9 Merced River Ranch Channel-Floodplain Restoration: Post-Implementation Monitoring Plan (Stillwater Sciences 2006). Metrics outlined in this plan have been consolidated and revised to better fit the project's target objectives and the focus of AFRP and to make use of some of the newest tools available in ecosystem science. The monitoring program for this project has been developed specifically to test hypotheses about habitat recovery processes. Several authors have noted the utility of designing restoration projects as experiments to test hypotheses regarding the physical and biological responses to restoration actions, and to develop a better understanding of process-based approaches in restoration science (Simenstad and Thom 1996; Roni et al. 2005; Merz and Moyle 2006). In order to understand the cause and effect relationships in restoring system processes, both effectiveness and validation monitoring are needed to learn from both failures and successes (Roni et al. 2005). This project integrates restoration actions, public outreach, monitoring, and adaptive management to better restore habitat in the Merced River, and provide an example for other Central Valley rivers.

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INTRODUCTION

In 1998, the California Department of Fish and Game (CDFG) acquired the Merced River Ranch (MRR) with the goals of protecting riparian habitat, improving conditions for salmonids, and supporting some public access. Restoration planning began with Phase I of the Merced River Corridor Restoration Plan, funded by U.S. Fish and Wildlife Service's Anadromous Fish Restoration Program (AFRP). The Merced River Stakeholders (MRS) and Technical Advisory Committee (TAC) were established during Phase I planning, and tasked with providing input throughout the duration of the project. The primary goal of Phase I was to provide a technically-sound, publicly-supported and feasible plan to restore habitat for fish populations in the lower 52 mi (84 km) of the Merced River. The plan extent is from Crocker-Huffman Dam to the confluence with the San Joaquin River, and includes the Dredger Tailings Reach (DTR) in which MRR is contained.

Phase II of the process was funded by CALFED in 1998, and consisted of baseline investigations into the geomorphic and riparian vegetation characteristics of the project reach (Stillwater Sciences 2001a). These investigations include the DTR and also identify social, institutional, and infrastructural opportunities and constraints for restoration (Stillwater Sciences and EDAW 2001). In 2000, CALFED funded Phase III that included the development of the Merced River Corridor Restoration Plan (Stillwater Sciences 2002) and a series of public workshops to present the plan and receive input from MRS, TAC, and the public.

The Restoration Plan identifies objectives and actions based on the scientific understanding of the Merced River. To guide restoration planning and address the various environmental impacts in the DTR, the Plan identified the following specific restoration objectives:

- Balance sediment supply and transport capacity to allow the accumulation and retention of salmonid spawning gravel;
- Restore floodplain functions that foster recruitment of riparian vegetation and the quality of riparian habitat;
- Increase in-channel habitat complexity to improve aquatic habitat for native aquatic species; and
- Re-engineer the low-flow and bankfull channel geometry so that it is scaled to function properly under current (regulated) flow conditions and to prevent riparian vegetation encroachment in the active channel.

From 2003-2006, Phase IV of the planning process built upon the Phase III plan with funding from the California Bay-Delta Authority (CBDA). The Phase IV objective was to design pilot floodplain and channel restoration experiments at MRR to initiate the restoration of natural ecosystem function, and to develop monitoring and evaluation plans to improve scientific understanding of the driving processes for floodplain restoration and inform future projects.

In Phase V of this work the project plan will be reviewed, revised, permitted, and implemented, building on the work of the previous phases. All actions will be carefully monitored to document implementation results, the effectiveness of the project at providing habitat for salmonids, and to validate the core assumptions of the project through controlled experiments.

All monitoring will be focused to address the goals of AFRP and to inform similar projects elsewhere in the Central Valley.

Similar work has occurred successfully on the Mokelumne River. Project objectives included providing additional salmonid spawning gravels (~1,400 yds^3 annually; ~1,940 tons), and improving inter-gravel water quality. Merz et al. (2004) showed that rehabilitated sites produce 30-35% more fry than pre-existing degraded sites. Collaborative monitoring studies also showed that improving spawning habitat improves conditions for other salmon life stages, as well as benthic macroinvertebrate production (Merz and Chan 2005). Juvenile fish were found foraging in the side channel in densities of up to 2.71 fish m^2 (Heady and Merz 2006). Wheaton et al. (2004a, b) designed and monitored gravel placements using an integrated approach that assessed the status of salmonid spawning physical habitat conditions as an indicator of ecosystem health. Through restoration monitoring, these projects demonstrated the value of habitat restoration to native salmon populations. Although few studies have established relationships between the ability of habitat to produce salmon on a watershed scale and easily measurable habitat variables (Sharma and Hilborn 2001), restoration projects provide an opportunity to explore those links. Post-project monitoring developed as part of this project will draw on previous studies to evaluate the physical and biological parameters of ecosystem health, development, and productivity, in terms of juvenile rearing, egg-to-fry survival, and river ecosystem rehabilitation.

Vision

> *To restore (i.e., rehabilitate and enhance) channel, floodplain and riparian ecosystem processes and critical habitats for juvenile and adult salmonids, in coordination with local communities and stakeholders, to promote the recovery of healthy and diverse Chinook salmon and steelhead populations in the Merced River, while helping to meet the abundance goals of the Anadromous Fish Restoration Program (AFRP)*

This vision fits into the framework of salmonid population recovery on the Merced River and is aligned with the following AFRP goals to: 1) involve local partners in the implementation and evaluation of restoration actions; 2) improve habitat for all anadromous life stages through improved physical habitat; and, 3) collect fish population, health and habitat data to facilitate evaluation of restoration actions (USFWS 2001). The vision is considered in the context of historic land use and current water management constraints and meets objectives outlined in previous planning efforts for the Merced River Ranch (Stillwater Sciences 2006).

Goals

1) To serve as an example of publicly-supported applied fisheries and restoration science;
2) To augment, rehabilitate and enhance productive juvenile salmonid rearing and adult spawning habitat in the Merced River; and,
3) To determine project effectiveness with an efficient and scientifically-robust monitoring program.

These goals fit into the framework of AFRP, and meet the AFRP and CALFED requirement to use adaptive management in planning, design, and implementation (CALFED 2001). The goals from the draft plan (CALFED ERP 02-P12-D) have been incorporated here and refined. Our target objectives are focused on AFRP goals and meet most of the previously defined objectives from the draft plan.

Target Objectives

Realistic target objectives are an important component of our approach to clearly address project goals. Detailed actions provide the necessary steps to achieve the target objectives. Iterative review of these actions is essential to determining the reliability in each particular step to meet the parameters of the project goal. The Project Plan with the following components (i.e., Community Outreach Plan, Design Standards, and Monitoring Program) and associated target objectives were developed to meet the aforementioned project vision and goals for the Merced River Ranch (MRR) and channel and floodplain restoration project. Furthermore, the target objectives consider the following seven goals outlined in the MRR planning documents in more detail which include: 1) restoring hydrologic and hydraulic functions; 2) restoring geomorphic processes; 3) restoring and enhancing habitat for native fish, plants and other species; 4) preserving, restoring and actively managing upland habitats and native species of value; 5) facilitating management of the MRR as a long-term supply of coarse sediment for regional restoration projects; 6) improving public understanding of restoration; and, 7) facilitating improvement of public education and recreation opportunities (Stillwater Sciences 2005).

Goals 1 through 4 are addressed by the Design Standards, goal 4 is also addressed by the Monitoring Program, while goals 6 and 7 are addressed by the Community Outreach Plan and Monitoring Program. Goal 5 will not be directly addressed as part of this project, although gravel will be excavated, cleaned, sorted and stockpiled.

1) ***<u>Community Outreach Plan (COP)</u>****: To serve as an example of publicly-supported applied fisheries and restoration science, the project will*:

a) provide a range of outreach opportunities to promote the value of river restoration to local community members and user groups;

b) promote a stewardship program for the river that integrates individual projects into the framework of common visions and goals of local, state and federal endeavors;

c) incorporate the values of the community into the project (e.g., aesthetic values, flood control, socio-economic needs of the community, etc.); and,

d) contribute to the development of educational programs and recreational opportunities.

2) ***<u>Design Standards</u>****: To effectively augment, rehabilitate and enhance productive juvenile salmonid rearing and adult spawning habitat, the project will*:

a) incorporate the project into an ecologically-sound, ecosystem context by designing the project to function under current water management constraints (i.e., magnitude and duration);

b) reestablish channel and floodplain habitat connectivity and complexity to restore ecological processes at the proposed project site to increase the availability and maintenance of channel and floodplain habitats;

c) create habitat conditions suitable for juvenile Chinook salmon rearing (i.e., fry and sub-yearling smolts);

d) create habitat conditions suitable for adult Chinook salmon spawning, egg incubation and development;

e) utilize existing habitat features to the maximum extent possible; and,

f) preserve and/or increase native vegetation as the dominant plant community.

3) ***Monitoring Program****: To evaluate project success by developing an efficient and scientifically-robust monitoring program to properly document implementation, determine effectiveness, and validate assumptions regarding benefits for salmonids, we will*:

a) conduct implementation monitoring to document the project was installed according to design standards and meets permitting requirements for sensitive and listed species;

b) conduct effectiveness monitoring to document ecosystem dynamics and habitat conditions with a Before-After-Control-Impact (BACI) study design; and,

c) conduct validation monitoring (i.e., experiments) to test hypotheses about the benefit of recovered river landscapes to rearing and spawning salmonids.

Monitoring Perspective

Our monitoring program will take an 'Ecosystem Perspective' as described by the Adaptive Management Forum (2002) by tracking physical and biological parameters; and the structural and functional responses by the restored ecosystem. Following suggestions from the Forum, we will consider alternative paradigms of ecosystem restoration when developing our project conceptual designs; develop an action plan to incorporate monitoring information and provide a framework for adaptive management; continue to clearly define quantifiable short- and long-term goals; and, include performance criteria to describe ecosystem function. We will ensure links in scientific input, project design, and implementation factors are intact and continuously refined.

Considerable debate about the effectiveness of restoration projects (Reeves et al. 1991; Kondolf 1995; Roni et al. 2002), in addition to the substantial investment of public funds, make it incomprehensible that monitoring is not an essential element of every restoration project (Roni and Quimby 2005). Monitoring is important to determine the environmental characteristics of a particular site. The parameters measured are critical physical and biological drivers of habitat and are intended to detect environmental change. Specific indicators (e.g., fish performance) are used that determine a value at a specific time (status), and with continued monitoring changes in the value across time at the same location (trend) can be determined. By designing monitoring programs to follow trends, the state of the system, especially restored systems, can be determined. Monitoring is critical for adaptive management (Karr and Chu 1997). Detecting and recognizing meaningful change in complex natural systems is difficult, because the systems are dynamic and heterogenous. Ecosystems maintain dynamic variation within predictable bounds (Chapin et al. 1996), but often these bounds are unknown with restoring systems.

Understanding fish use, diet composition, and ultimate success (i.e., exit Merced River) is important to determine the effectiveness of the habitat restoration. It is critical to understand if the fish are using the habitat, if the links to the prey resource are intact, and if the availability of the site contributes to the overall success of the fish in river rearing.

Efficient and scientifically-robust monitoring provides the measure of success for any restoration project, and was noted as a critical element in Phase IV. The following monitoring plan has been adapted from the Technical Memorandum #9 Merced River Ranch Channel-Floodplain Restoration: Post-Implementation Monitoring Plan (Stillwater Sciences 2006). Metrics outlined in this plan have been consolidated and revised to better fit the project's target objectives and the focus of AFRP and to make use of some of the newest tools available in ecosystem science.

Integrating with Other Monitoring Programs

This monitoring program will be designed to integrate with the other long-term monitoring occurring in the Merced River, as possible. From 2007–2009, the USFWS supported CFS to monitor juvenile salmonid out-migration in the Merced River. This monitoring program determines annual juvenile Chinook salmon and *O. mykiss* production using rotary screw traps (RSTs) at Hatfield State Park (Hatfield; rkm 3.2), and quantifies emigrants to the San Joaquin River (Watry et al. 2007, 2008). This data set is intended to provide a valuable source of information for evaluating fish responses to in-river management actions (CAMP 1997). The primary objectives of this project are: 1) estimate abundance of juvenile salmonid out-migrants in the lower Merced River using RSTs operated near Caswell; and, 2) determine and evaluate patterns of timing, size, and abundance of juveniles relative to flow and other environmental conditions. This juvenile salmon monitoring program helps AFRP and CAMP address their goals to track population dynamics, evaluate the results of past and future habitat restoration efforts, and to understand the impacts of instream flow schedules and management on the fall-run Chinook salmon population. The Merced Irrigation District (MID) has also funded ongoing juvenile salmonid population monitoring at Cressey (rkm 43.5). Natural Resource Scientists, Inc. has been conducting the monitoring effort to determine the in-river spawning success by tracking the number of fry produced. The effort also provides information about *O. mykiss* and other fish species able to be collected by RST.

Our monitoring efforts to assess habitat restoration on the Merced River may be coupled with ongoing juvenile out-migration monitoring programs. In addition to quantifying any change in population status, these monitoring efforts can potentially be used to track the success of juveniles using restored habitats. During post-project monitoring activities at restoration sites, juvenile salmonids may be collected on site, and marked during processing for other data. The collection of marked fish at Hatfield would indicate successful rearing and migration, and document the potential benefits of restored rearing habitat to the population. The size and condition of fish may also indicate improvements in rearing conditions, although a detectable signal may be difficult to obtain due to the overwhelming impact of the other limiting factors in the river. Similar protocols are being conducted in Clear Creek following floodplain rehabilitation (M. Teubert, pers. comm., 2008). Note, current population levels may make probability of recapture very small, especially if monitoring efforts are reduced or eliminated.

Adult spawning surveys are currently conducted by CDFG each fall in the Merced River. These surveys include an estimate of adult escapement based on numbers and redd surveys. Our monitoring program intends to augment these monitoring efforts by providing additional assistance in adults or redd surveys. The CDFG also has a variety of other surveys for juvenile salmonids in the lower San Joaquin and delta, which may provide additional opportunities for synergistic monitoring activities.

Active Experimentation

Monitoring of long-term project effectiveness and the implementation of comparative studies needs to be given a higher status, adequately supported, and made more effective (AMF 2004). Each restoration project is another opportunity to further the science of restoration ecology, by testing hypotheses. Restoration projects allow researchers to test theories in habitat function and apply them to restoration design (i.e., channel width, riffle/pool size, meander radius, elevation, and riparian community structure, etc.) (AMF 2004). Using active experimentation to address how well restoration projects conform to the underlying conceptual models is important (AMF 2004) and can provide supporting evidence to validate underlying assumptions about recovering habitat function with specific actions. These studies will also inform ongoing efforts to restore habitat with detailed information about recovering habitat condition and productivity. As with all monitoring activities, studies should be well-designed with clear target objectives and criteria with robust analyses of results. This restoration monitoring program takes a hypothesis-testing, science-based approach to address a series of questions about river restoration and restoring ecosystem function at the MRR. This approach follows recommendations from the CVPIA Independent Review Panel (Circlepoint 2008).

Partnering with AFRP and the Community

This monitoring program will occur with the contribution of AFRP and potentially interested community members. We anticipate AFRP staff members will assist with periodic data collections including aquatic habitat sampling, vegetation and topographic surveys. Anadromous Fish Restoration Program staff will also assist during validation experiments. We also anticipate the potential to meet interested community members at the public outreach functions who may be interested in assisting with data collection on site. Through a coordinated effort, more detailed monitoring can be accomplished and partnerships with interested parties strengthened.

APPROACH

Background

Assessment of restoration actions should include three types of monitoring: implementation; effectiveness; and validation (MacDonald et al. 1991; Kershner 1997; Mulder et al. 1999). Time scales, project aspects, and objectives addressed will vary among types of monitoring (Table 1).

Table 1. Monitoring types for the MRR restoration project (Stillwater Sciences 2006).

Type of Monitoring	Question Addressed	Time Frame
Implementation	Was the project installed as planned?	1 – 6 months
Effectiveness	Was the project effective at meeting restoration objectives?	1 year to decades
Validation	Are the basic assumptions behind the project conceptual model valid?	5 – 10 years

We are following this conceptual model for monitoring. The following outlines questions addressed as part of the three types of monitoring for the MRR project. As recommended in Phase IV, we have developed a series of experiments to test habitat function for adult and juvenile salmonids in terms of egg-to-fry survival and juvenile rearing performance, and to determine the conditions controlling native vegetation community development. The results of these experiments are expected to improve future restoration projects in the DTR, and inform fisheries scientists with a regional-level understanding of ecosystem dynamics in the Sacramento-San Joaquin watersheds. This project will provide an essential contribution to the goals of the California Bay-Delta Authority as well as others.

Implementation Monitoring

Implementation monitoring will determine if the restoration project was implemented according to the design plan, and met the goals of the project design. Generally, monitoring occurs after construction is complete, however some aspects will be carried out during implementation as a check on design appropriateness (Kershner 1997). Mid-course corrections can be made as appropriate. In addition to tracking the success of the implementation in terms of physical structure, we will also investigate the restored channel and floodplain function in terms of hydrology and flooding inundation. The frequency and duration of flooding is among the primary drivers of habitat productivity in terms of accessibility for fish, prey resource production, and habitat maintaining processes (Hill et al. 1991; Tockner et al. 2000). Projections were established during the project design planning for frequency and duration of inundation. To determine if the project was installed as planned, the following monitoring components will be addressed (Table 2):

Table 2. Implementation monitoring components (Stillwater Sciences 2006), revised.

Component	Question(s)	Parameter	Timeline
C1. *Constructed topography/bathymetry match those in project design.*	Does the constructed topography/bathymetry match design plans?	Topography and Bathymetry	During and Immediately following construction; September 2010
C2. *Inundation frequency and duration matches target objectives.*	Does duration and magnitude of flooding match design plans?	Discharge, groundwater level, flooding inundation, rate of recession	Following construction, then continuous; October 2010 – September 2013

Effectiveness Monitoring

Site-specific effectiveness monitoring will track physical conditions and biological responses necessary to provide productive rearing and spawning habitat for salmonids. Effectiveness monitoring is complex and requires evaluating the outcomes of multiple objectives relating physical, biological, and biogeochemical factors at work in the river-floodplain ecosystem (Stillwater Sciences 2006). The following parameters are among those physical parameters important for understanding function in aquatic habitats: water temperature, DO, turbidity, hyporheic flow and water quality. Documenting channel bathymetry and on-site coarse sediment supply budgets are also critical to understanding habitat function. Terrestrial parameters of the floodplain may include topography and flooding inundation. We also track the biological response in the side channel and floodplain in terms of fish use and residence, invertebrate production, fish foraging success, diet composition and potential growth, vegetation characteristics, and use the information to explore links to physical conditions.

The monitoring plan will track the physical and biological parameters closely related to each of the target objectives outlined in the project plan, and determine the effectiveness of the design in restoring target habitat conditions. In keeping with the approach of adaptive management and environmental monitoring, pre-determined metrics and success criteria are given with each target objective, and the approach is designed to test the hypotheses associated with the project. The primary question to be answered by the effectiveness monitoring is: was the project effective at meeting restoration objectives?

The following null and alternate hypotheses will be tested to determine the effectiveness of gravel augmentation, recovered side channels and seasonally inundated floodplain habitats to recovering habitat for juvenile and adult salmonids (Table 3).

Table 3. Effectiveness monitoring hypotheses, questions, and parameters measured.

Hypothesis	Question(s)	Parameters Measured	Timeline
$H1_0$: *Restoring floodplain processes in the Merced River does not result in improved habitat conditions for salmonid rearing habitat.* $H1_a$: *Restoring floodplain processes in the Merced River results in improved habitat conditions for salmonid rearing habitat.*	Are habitat conditions in project area suitable for juvenile Chinook salmon rearing? Are conditions following restoration significantly different than reference sites?	Flooding Inundation Water Velocity/Depth Water Temperature Dissolved Oxygen Turbidity Fish Surveys Macroinvertebrates	February, March 2010 – 2013 April, May 2010 – 2013
$H2_0$: *Restoring in-channel coarse sediment processes in the Merced River does not result in improved habitat conditions for salmonid spawning habitat.* $H2_a$: *Restoring in-channel coarse sediment processes in the Merced River results in improved habitat conditions for salmonid spawning habitat.*	Are habitat conditions in project area suitable for adult Chinook salmon spawning? Are conditions following restoration significantly different than reference sites?	Permeability Channel Bed Surface Composition Composition at Depth with Bulk Sampling Sediment Dynamics Spawner Surveys	October, November 2010 – 2012
$H3_0$: *Restoring floodplain processes in the Merced River does not result in improved conditions for native vegetation communities.* $H3_a$: *Restoring floodplain processes in the Merced River does result in improved conditions for native vegetation communities.*	Was there an increase in native vegetation in the project area? Was the cover of non-native invasive plant species reduced or prevented?	Photo Points Project Area Vegetation Mapping Field-Collected Vegetation Data Soil Characteristics Groundwater Level	June, July 2010 – 2013

These questions align with the target objectives for the overall project, and the following methods are for periodic and continuous tracking of those parameters outlined. By using the hypothesis testing approach and answering detailed questions associated with the project, we will be able to monitor the project's effectiveness and provide detailed information to inform ongoing restoration for salmonids throughout the Central Valley.

Validation Monitoring

As introduced in the Phase IV monitoring plan, validation monitoring is carried out to verify the underlying assumptions of the project conceptual model, and as a consequence this type of monitoring has a research focus (Kershner 1997). In Phase IV, validation monitoring focused on the responses of fish, birds, invertebrates, and riparian vegetation to the re-scaling of channel and floodplain morphology intended to match the contemporary, regulated flow regime (Stillwater Sciences 2006). In addition to documenting ecosystem responses with effectiveness monitoring, as described in Phase IV, we will conduct experiments to assess relative habitat function between the BACI sampling sites. These studies are designed to provide support to the previously stated hypotheses and to primarily address the following question: are the basic assumptions behind the project conceptual model valid (i.e., does the project contribute to increased productivity for Chinook salmon populations in the Merced River)?

We will assess benefits to spawning Chinook salmon of gravel-bed enhancement following methods outlined in Merz et al. (2004) and Wheaton et al. (2004a, b), and use a bioenergetics model to assess juvenile Chinook salmon performance in the non-restored and restored sites. The bioenergetics model is a powerful tool to assess habitat in terms of potential fish growth and has been used by other researchers aiming to assess restoration success (Brandt et al. 1992; Mason et al. 1995; Tyler and Brandt 2001; Sommer et al. 2001; Madon et al. 2001; Gray 2005). The model's energy-balance approach estimates growth as food consumed (C) minus the energetic costs of respiration (R), specific dynamic action (cost of processing a meal) (S), and wastes (egestion (F) and excretion (U)). Model inputs will include site-specific temperature, fish size, diet composition and prey energy content. The bioenergetics model (Hanson et al. 1997) is a simple, mass-balance equation that determines fish growth through established physiological relationships and those factors with the largest effect on growth: consumption rate, food composition and quality, and temperature. By evaluating modeled growth potential in foraging fish, the relative benefit of foraging in restored habitats can be quantified.

By demonstrating the benefit available to spawning and rearing fish, especially in the BACI context, the work should increase our understanding of mechanisms of channel enhancement and floodplain restoration, and the links between healthy ecosystem, hydrologic and geomorphic processes (Merz et al. 2004; Wheaton et al. 2004a, b). The following hypotheses will be tested to determine the benefit of gravel augmentation, recovered side channels and seasonally inundated floodplain habitats to juvenile and adult salmonids (Table 4).

Table 4. Validation monitoring hypotheses, questions, and parameters measured.

Hypothesis	Question(s)	Parameters Measured	Timeline
$H1_0$: Restoring floodplains in the Merced River provide no productive salmonid rearing habitat. $H1_a$: Restoring floodplains in the Merced River provides productive salmonid rearing habitat.	Does restoring floodplain processes recover productive habitat for salmonid rearing?	Juvenile Growth Potential determined with Bioenergetics Model -fish size, diet composition, consumption rate, prey energy content, and temperature conditions	February, March 2011 – 2012
$H2_0$: Restoring in-channel coarse sediment processes in the Merced River provides no productive salmonid spawning habitat. $H2_a$: Restoring in-channel coarse sediment processes in the Merced River provides productive salmonid spawning habitat.	Does restoring in-channel coarse sediment processes recover productive habitat for salmonid spawning?	In Situ Egg-to-Fry Survival with Egg Tubes -change in size and survival	October, November 2011 – 2012
$H3_0$: Restoring floodplains in the Merced River does not restore ecosystem processes that lead to an increase in native vegetation cover and complexity. $H3_a$: Restoring floodplains in the Merced River does restore ecosystem processes that lead to an increase in native vegetation cover and complexity.	Does restoring floodplains recover ecosystem processes that affect the success of natural native plant recruitment?	Flooding inundation Sediment dynamics Woody plant recruitment	June, July 2011 – 2012

Study Design

The field sampling has been designed to collect data to inform the concepts, hypotheses and questions from each type of monitoring, and address project target objectives. Monitoring efforts may occur across the entire project site (e.g., topography surveys), or be concentrated in permanent sampling plots (determined through a stratified-random sampling design). Samples will be collected before and after project implementation. The Before-After-Control-Impact (BACI) study design structure is used to test the differences between the non-restored and restored sites (Green 1979; Stillwater Sciences 2006). This approach can utilize a paired series of Control-Impact sites, subjected to a series of Before-After replicated measurements, referred to as the paired BACI design (Bernstein and Zalinski 1983; Stewart-Oaten et al. 1986; Smith 2002). Robust statistical assessment is possible because of the spatial and temporal replication.

Relevé field sampling (CNPS 2007) is used for vegetation data collection. This protocol follows methods of vegetation community sampling and mapping developed by the California Native Plant Society and CDFG to meet the standards developed by the Federal Geographic Data Committee (Jennings et al. 2009). These standards have been submitted to the State Legislature as vegetation mapping standards for California (CDFG Item 3600-001-0001). Furthermore, the San Joaquin Valley has been identified by CDFG as a high priority area for vegetation sampling, classification and mapping (CDFG 2007). The relevé provides detailed quantitative measures of vegetation structure, composition and cover dominance that are collected efficiently, analyzed statistically and accurately repeatable across time by trained personnel. It also collects habitat information per the California Wildlife-Habitat Relationships System (see http://www.dfg.ca.gov/biogeodata/cwhr/). Additionally, we will map woody stem recruitment within a gridded subplot of each relevé.

Before and after channel bathymetric and floodplain topographic surveys will document the dimensions and elevations within the project area. Additionally, topographic surveys will be conducted on an annual basis to monitor the project area and fluctuations in bed elevation resulting from sediment deposition and scour and, potentially, lateral shifts of the channel. Changes are expected as part of the natural function of the river landscape, and a better understanding between the topographic characteristics and biological function will be enabled by these data collections. Cross-section and longitudinal profile surveys will provide detailed documentation of elevations, dimensions, and forms of the main channel and floodplain.

Understanding the hydrology of the project area is essential for testing nearly all of the project hypotheses. Current hydrology will be compared with the results of the hydraulic models (developed during the planning process) to compare with predictions. Pressure transducers will also log the timing and duration of the river stage, and can therefore be related to habitat requirements for both salmonid and riparian tree species. These data can be compared with biological information on salmonids and riparian vegetation to evaluate if favorable habitat conditions for these species were achieved. Pressure transducers will also provide an important check on the actual discharge required for floodplain inundation. Groundwater wells can be installed to monitor groundwater water quality. Water quality monitoring will also be a component of regulatory monitoring during project construction and gravel augmentation activities.

We will use a variety of methods to monitor substrate characteristics and dynamics. Data will be used with bathymetric and topographic information to determine the frequency and magnitude of sediment transport in the restored reach. Substrate characteristics will be determined using pebble counts (see below) while tracer rocks and scour chains will provide information on bed mobility. Incubating embryos are affected by gravel permeability, dissolved oxygen, and gravel particle size composition (Barnard and McBain 1994). Measures of gravel permeability determine the flow of water through the channel bed material. These measurements can be directly used to calculate an index of survival-to-emergence for salmonids and can provide a rough indication of expected salmonid fry abundance (Stillwater Sciences 2006).

Relative fish abundance and diet composition will be evaluated at aquatic habitat sampling sites by multi-pass electrofish sampling (Reynolds 1996; Van Deventer & Platts 1989) and gastric lavage (Haley 1998; Koehler et al. 2006). These methods allow collection of information on densities and diet composition *without mortality*. Diet samples will be processed following standard procedures described in Terry (1977) and Gray et al. (2002). Diet composition information may also be available (by gastric lavage) of fish obtained during the ongoing RST operations, if necessary (see below). A relative consumption rate will be determined by assessing the weight of the stomach contents to the weight of the fish (ration). Prey energy will be generalized using literature values. Several studies have suggested the use of models to assess habitat (Madon et al. 2001), or used it to assess relative conditions in a restored floodplain (Sommer et al. 2001). These data will provide critical information to address questions associated with implementation, effectiveness and validation. Our intent is to document that the project was implemented according to design plans, is effective in terms of providing habitat for riparian vegetation and salmonids, and validates project assumptions regarding the potential productivity for salmonids by restored river landscapes.

A critical component of monitoring habitat function is gathering information on the macroinvertebrate community. Invertebrates are also important indicators of ecosystem health (Kearns and Karr 1994). Macroinvertebrates are sensitive to environmental change and have been used by many studies to assess restoration success (e.g., Gray et al. 2002; Merz et al. 2004). Additionally, juvenile salmonids primarily feed on a variety of benthic macroinvertebrates and other drift insects.

Sampling Sites

Sampling sites will be stratified and randomized in the BACI context, and replicate samples will then be collected. Sampling sites will be upstream (Merced Irrigation District, MID), within (Merced River Ranch, MRR), and downstream (Snelling) of restored reaches. The following diagram depicts our basic sampling approach (Figure 1) and schematic for vegetation sampling (Figure 2). Table 3 summarizes the monitoring parameters, equipment needs, frequency, and other important aspects of the overall monitoring program.

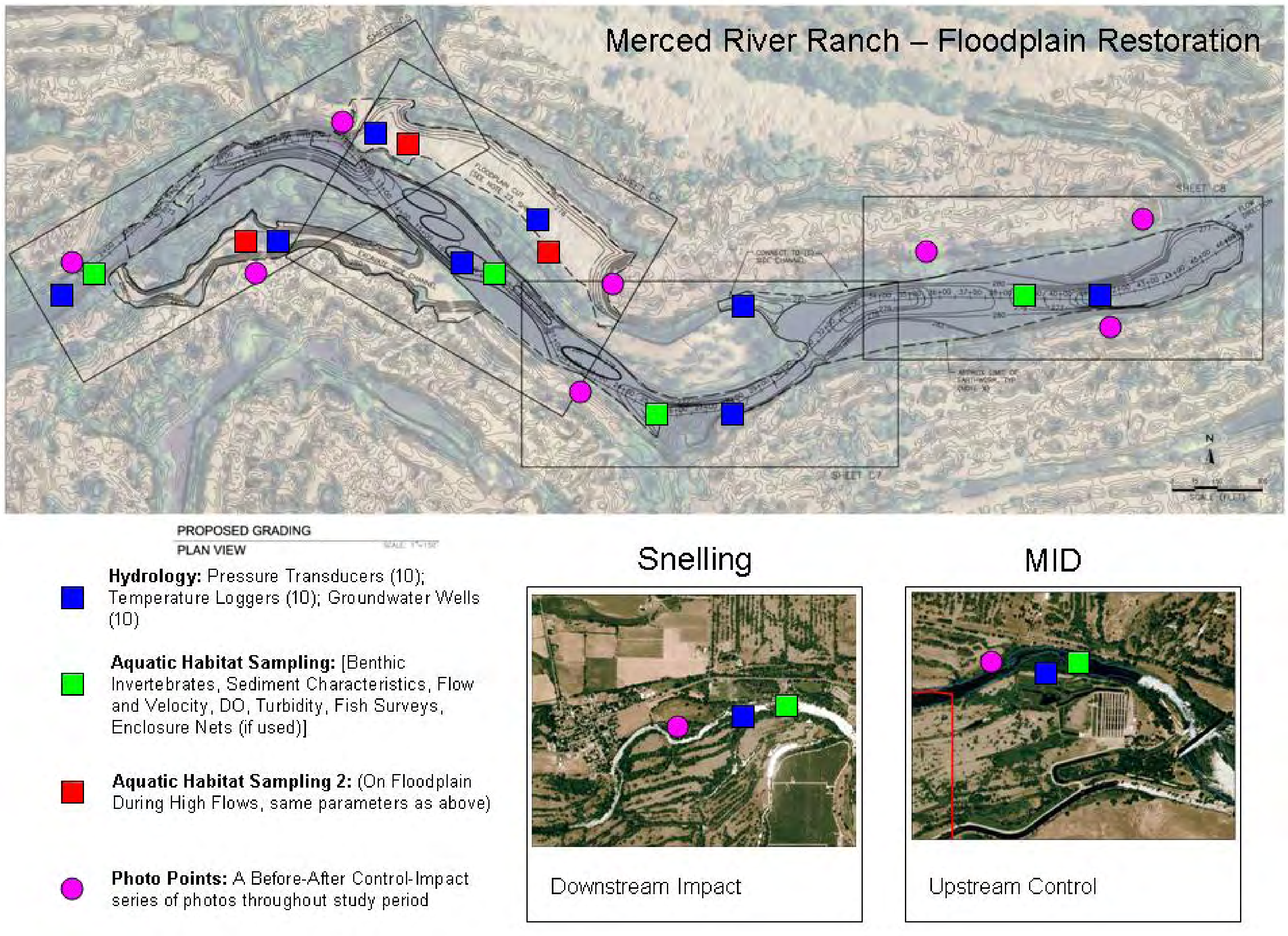

Figure 1. Merced River Ranch Project General Sampling Schematic.

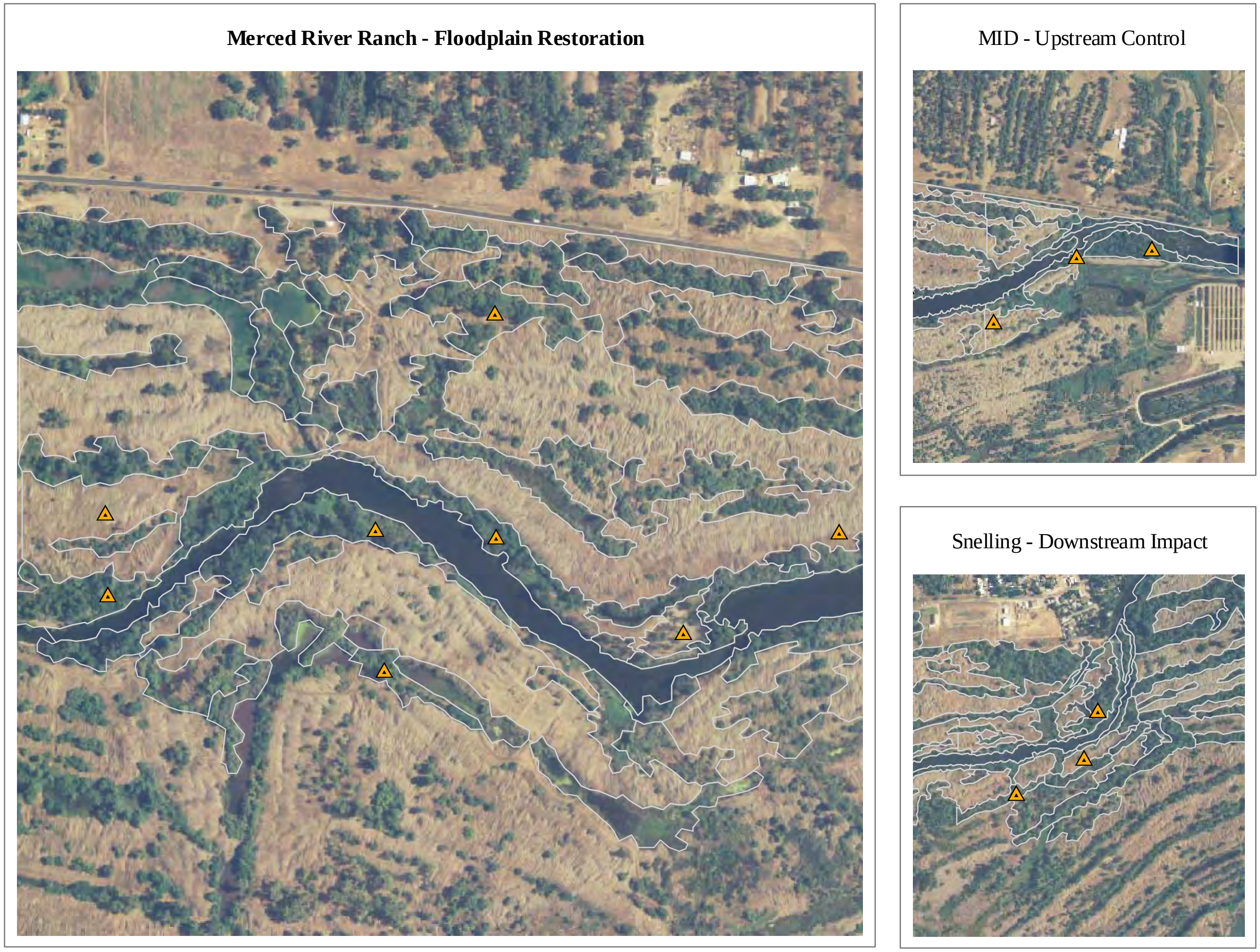

Figure 2. Merced River Ranch Project Vegetation Sampling Schematic.

Table 5. Monitoring study design and additional details.

Monitoring Parameter	Description/Use	Field Equipment	Personnel	Time Period Collected	Permitting Req	Implementation	Effectiveness	Validation
Hydrology								
Discharge	Determine outflow conditions	NA	MID	entire project period				
Flooding Inundation and Rate of Flow Recession	Determine frequency and duration of flooding events before and after restoration actions	Pressure Sensors	CFS	entire project period		X	X	
Water Velocity	Assess instantaneous habitat conditions	Flow Gauge	CFS	seasonally			X	
Water Depth	Assess instantaneous habitat conditions	Flow Gauge	CFS	seasonally			X	
Groundwater Levels	Track groundwater conditions for hydrological impacts and vegetation	YSI, turbidimeter, ??	CFS?	seasonally			x	
Topography/Bathymetry								
Topographic Surveys	Determine elevations across project site	Survey Equipment	PWA/CFS	annually		X		
Bathymetric Surveys	Determine depths in river mainstem	Sounder, etc.	PWA/CFS	annually		X		
Cross-sectional Surveys	Determine elevations at several randomlly distributed cross-sections	Survey Equipment	PWA/CFS	annually		X		
Sediment Characteristics								
Permeability	Determine level of embeddedness	Stand Pipe	CFS	seasonally			X	X
Surface Composition	Determine surface substract composition	Pebble Counts	CFS	seasonally			X	X
Sediment Dynamics	Determine sediment mobility and transfer	Tracer rocks, scour chains	CFS	seasonally			X	
Bulk Composition	Determine % fines	Bulk Sampling	CFS	annually			X	X
Water Quality								
Temperature	Assess instantaneous habitat conditions	TidBit Continuous Data Logger	CFS	continuously	X		X	X
Dissolved Oxygen	Assess instantaneous habitat conditions	DO Meter	CFS	seasonally	X		X	
Turbidity	Assess instantaneous habitat conditions	Turbidity Meter	CFS	seasonally	X		X	
Mercury Testing	Monitor potential for mercury contamination	Sampler	??	???	X	X		
Biological Conditions								
Photo Points	Document general changes in the system following restoration actions	Digitial Camera and tripod	CFS	seasonally		X	X	
Vegetation Characteristics	Track vegetation conditions in the project site and an adjacent reference	Field survey equipment	botanist	annually		X	X	X
Wildlife Surveys	Track wildlife activity and use in the project area	Binoculars, GPS	CFS	seasonally	X	X		
Fish Surveys	Determine juvenile fish presence and abundance at project site; Conduct Redd surveys using GPS; Install egg tubes; Use enclosure nets to determine site-specific fish diets and consumption rates;	Beach Seine, Electrofisher, Gastric Lavage Equipment, GPS, etc.	CFS; CDFG	seasonally		X	X	X
Prey Resource Supply	Determine prey resource availability and composition	Hess Sampler, Drift Collector	CFS	seasonally			X	X

METHODS

The following provides detailed descriptions of the methods used for the various monitoring efforts described in this program. The main objective of monitoring is to address our questions and hypotheses using sound science with targeted, efficient sampling and high quality data standards. Standard methods will be used for most monitoring activities and appropriate statistics will be applied to the results to test our hypotheses. All field activities will be conducted with qualified personnel trained in first aid and all safety precautions.

Spatial Database

Global Position System (GPS)

The CFS team will collect as much monitoring information as possible with location information using the Trimble GeoXT (GeoExplorer 2008 series). Data dictionaries will be built using the PathFinder Office™ software package to simultaneously enable easy collection of survey and location information. Data will be downloaded and post-processed immediately (within 24 – 48 hours), keeping in mind base stations are generally updated every 24 hours. Post-processed data will be checked for errors and stored with backups created periodically.

Geographic Information System (GIS)

The CFS team will use ESRI (www.esri.com) GIS to collate and summarize some of the physical and biological data collected by this monitoring program. The GIS links the spatial information obtained by GPS to photos, data tables, and other files. This spatial database system can be queried to obtain information to apply to other analyses (e.g., bioenergetics, vegetation controls, etc.). Field collected GPS data are exported into .shp files which are then opened with ArcView 9.2 software package. Exchange of data layers is facilitated by this spatial database.

Hydrology

River Discharge and Flooding Inundation

We will use discharge data from Crocker-Huffman Dam (gage operated by Merced ID) in conjunction with stage data from pressure transducers placed in the channel and floodplain of the restored reach to determine flooding inundation in terms of duration and magnitude of flows.

a) Discharge – provided by MID and summarized. On-site data also collected using flow transect method described below. Flow transect measurements will be collected at variable flows (approximately every 250 – 400 cfs) and related to on-site stage measurements to develop a site-specific flow-stage relationship.

b) Flooding Inundation (i.e., Duration and Magnitude) – a series [i.e., 10] of continually recording in-channel and floodplain pressure transducers (e.g., Onset Computer Corporation; HOBO® 30-Foot Depth Data Logger) will be used to determine magnitude and duration of inundation. Loggers will be downloaded quarterly and data summarized to evaluate flooding inundation compared with plan estimations. Locations of all pressure transducers will be recorded with sub-meter accuracy GPS.

Pressure transducers will be installed and topographically tied into five surveyed and monitored cross-sections within the MRR in the main channel. Installation of pressure transducers will be according to the manufacturer's specifications and downloads will occur periodically, or as necessary.

Water Velocity/Depth

Depth and water velocity will be measured at each sampling site before and after gravel augmentation and floodplain regrading. A Marsh-McBirney flowmeter (Flo-Mate Model 2000; Hatch Company) will be used for taking water velocity measurements at each sampling site, and depth will be measured with the top-setting wading rod. The unit uses an electromagnetic sensor to measure the velocity in a conductive liquid such as water. The velocity is in one direction and displayed on a digital display as feet per second (ft/s) or meters per second (m/s). The device measures water velocity using Fixed Point Averaging (FPA) which is defined as: average velocity measured over a fixed period of time (CFS uses a 30 second interval). At each site the depth of the velocity measurement varies depending on water depth. For depths less than 2 ft (0.6 m), water velocity is taken at 60% of depth (measured from water's surface). For depths greater than 2.0 ft (0.6 m), water velocity is taken at 20% and 60% of depth and averaged.

Flow Transects

Specific sites will be selected to perform flow transect measurements to determine localized river discharge. Site selection is based on the open channel profiling handbook (provided as part of flow meter manual). A rope or cable will be secured to the opposing banks perpendicular to the flow approximately 1 – 2 ft (0.3 – 0.6 m) above the water surface. The rope or cable will be pulled taught using a come-along or similar mechanical device. A measuring tape will be attached to the rope or cable using large binder clips at regular intervals (Figure 3). If the channels are too deep to wade, a small boat will be used. Water velocity and depth are measured at 1.6 ft (0.5 m) stations across the entire channel using a flow meter.

Figure 3. Technician attaching measuring tape to rope using binder clips in Merced River (left) and detail on attaching rope to measuring tape (right).

Discharge (*Q*) is then calculated using the following formula:

$$Q = \sum (V*D*W \text{ at each station})$$

where, V= average velocity, D=depth, W=width of station

Groundwater Levels

Groundwater wells are located at four points within the MRR, and two wells will be monitored so river stage and discharge can be related to relative changes in groundwater levels and water surface elevations. Information on groundwater will be included in the analyses on vegetation and other biological parameters to investigate the relationship between sub-surface water conditions and various biological responses.

Bathymetry and Topography

Depth Sounder and Total Station

Surveys will be made with a Trimble 4000 GPS receiver, Leica T-1600 theodolite, DI-1600 electronic distance meter, and NA-2002 electronic level to record thousands of individual reference points (i.e., latitude, longitude, elevation). Point spacing will be based on grade-breaks and channel topography instead of a uniform grid (Brasington et al. 2000). Bathymetric surveys will be conducted using traditional survey methods augmented by a fish-finding sonar/mapping GPS unit (Lowrance LMS-520C DF). The unit is mounted on a boat and powered by a 12-v marine battery. Location and water depth are recorded every second and stored electronically. Data are recorded using WGS-84 datum. The marriage of the survey and sonar/GPS data is achieved by recording like waypoints in the sonar/GPS unit and survey equipment. The depth data recorded by the sonar unit is then subtracted from the water surface elevation determined by the traditional survey method. Sediment budgets determine the relative channel stability and thus are a way of evaluating physical habitat change (Merz et al. 2006). To determine bed movement, volumetric assessment will be calculated over time.

Cross-section and Longitudinal Profile Surveys

A series of five cross-sections will be established in the project site and surveyed annually to document changes due to restoration activities along the extent. Cross-sections will also be used to evaluate if constructed floodplain elevations provide: 1) the desired elevations from groundwater (this will be evaluated in conjunction with groundwater monitoring), and 2) floodplain and secondary channel inundation depths suitable for juvenile Chinook salmon. The surveys of these cross-sections will occur concurrently with topographic/bathymetric work when feasible.

Water Quality

Water quality and temperature monitoring will be used to track water quality conditions and groundwater/river interactions. Ongoing temperature monitoring by CDFG and Merced ID, general water quality monitoring by USGS (2002), and recent data collected as a part of the MRR mercury assessment (Stillwater Sciences 2004c) suggest that water temperatures and basic water quality in the DTR are not currently impaired or detrimental to Chinook salmon life stages (Stillwater Sciences 2006). Restoration objectives focus on achieving water quality conditions that support rearing and spawning of Chinook salmon. By tracking the water temperatures, non-advantageous changes will also be detected. Specifically, providing a good understanding of the habitat conditions to ensure targets are met, and higher temperatures than expected do not lead to improvements in habitat conditions for non-native species.

Water Temperature

Continuously recording data loggers (TidBit^{TM}; Onset Computer, Inc.) for temperature will be installed throughout the main channel, side channels, and floodplain to verify that the restored habitats maintain acceptable water temperatures during salmonid spawning, incubation, and rearing life stages. Thermographs will be installed during pre- and post-project monitoring work to track the temperature conditions both before and after construction activities at control and impact sites. Thermographs throughout the main channel will evaluate temperature differences in varying habitats within the MRR. Thermographs will be installed and downloaded according to the manufacturer’s specifications.

Dissolved Oxygen

During seasonal field trips, dissolved oxygen data will be collected from each sampling location using an YSI Handheld Dissolved Oxygen (DO) Instrument (YSI; Model 550A). These spot measures are designed to determine if minimum criteria for water quality are met, and to meet effectiveness monitoring objectives by determining if performance criteria for DO are met.

Turbidity

During seasonal field trips, instantaneous turbidity will be measured in Nephelometric Turbidity Units (NTU) using a turbidity meter (LaMott Company; Model 2020). These spot measures are also designed to determine if minimum water quality criteria are met, and to meet effectiveness monitoring program guidelines.

Sediment Characteristics

The project objectives include developing an understanding of rates of scour and deposition while restoring ecological processes. Composition and dynamics of channel sediments must be understood to address these objectives. A variety of methods will be used to measure sediment characteristics and mobility. Data will be collected on permeability, surface composition, and sediment composition at depth. The following details the methods used.

Permeability

Before and after project implementation permeability measures will be taken from the sampling sites and replicated over time. Measurements will be taken using a stainless steel permeability standpipe, such as the modified Terhune Mark VI (Barnard and McBain 1994) (Figure 4). Inter-gravel permeability are taken along a transect, and will be measured at three replicate locations at each sampling site. Permeability measurements taken at sites outside the restored reach were monitored for permeability in 2004 and 2005 to compare gravel permeability of the restored and un-restored reaches (Stillwater Sciences 2006), and will be used to make comparisons with these data. At each depth a hollow rod attached to hand powered vacuum pump is lowered into the standpipe until it reaches a depth of 1 in (2.5 cm) below the water surface inside the pipe. The water is evacuated from the standpipe for a fixed time interval (typically ~20 seconds). The captured water volume and pumping time are used to calculate intergravel permeability and a water sample is retained to measure turbidity in NTU using a Lamott 2020 turbidimeter. Intergravel temperature and DO are measured by lowering a YSI (model 550A) probe into the standpipe. At each location, a full suite of water quality measures are taken at three different depths (i.e., 6 in (15.2 cm); 12 in (30.5 cm); and, 18 in (45.7 cm)). In all, data will be collected from eight on-site stations and from one station at each control site.

Figure 4. CFS biologists install a stand pipe (left) and measure intergravel permeability (right).

Channel Bed Surface Composition

To identify conditions of the channel bed surface, pebble counts following methods described in Merz et al. (2004) will occur along longitudinal and/or diagonal sampling transects (Figure 5). Substrate samples are collected by hand every 1.0 ft (0.3 m) along transects, and a round-holed template is used to measure size. A minimum of 50 pieces will be measured per transect and at least three transects will be sampled per site. Substrate will be categorized into 12 size classes: <8.0, 8.0, 16.0, 22.2, 31.8, 44.5, 63.5, 89.0, 127.0, 177.8, 254.0 and >254 mm. Categories are determined by the largest slot through which an individual pebble cannot pass (Merz et al. 2004). In all, data will be collected from eight on-site stations and from one station at each control site.

Figure 5. CFS biologists conduct pebble counts in the Merced River.

Determining Composition at Depth with Bulk Sampling

McNeil Core Sampler

Composition at depth will be determined using a McNeil Core sampler (McNeil and Ahnell 1964) to sample substrate size distributions. Four cores per year will be collected, along with two cores from side channel and floodplain. A McNeil core sampler (Figure 6) is constructed from two different sized cylinders, with the smaller cylinder functioning as a coring device and the larger upper cylinder acting as a collection basin preventing contamination of the sampled water column with outside water and sediment. Sample sites are chosen at random and core depth varies depending on substrate size. Site selection is limited to water depths that do not overtop the sampler, and special care is taken to minimize impacts during spawning and incubation periods. Bulk material is excavated and placed into buckets. Water containing suspended sediment is captured by placing a plug in the bottom of sampler and pouring contents into buckets. Samples are labeled and returned to the lab for analysis. In the lab, samples are dehydrated, sorted by size class and weighed to determine percent composition. Sometimes, larger materials (typically 0.3 in [0.8 cm] – 10 in [25.4 cm]) are separated and weighed in the field while smaller size classes are returned to the lab for dehydration and weighing. In all, data will be collected from eight on-site stations and from one station at each control site.

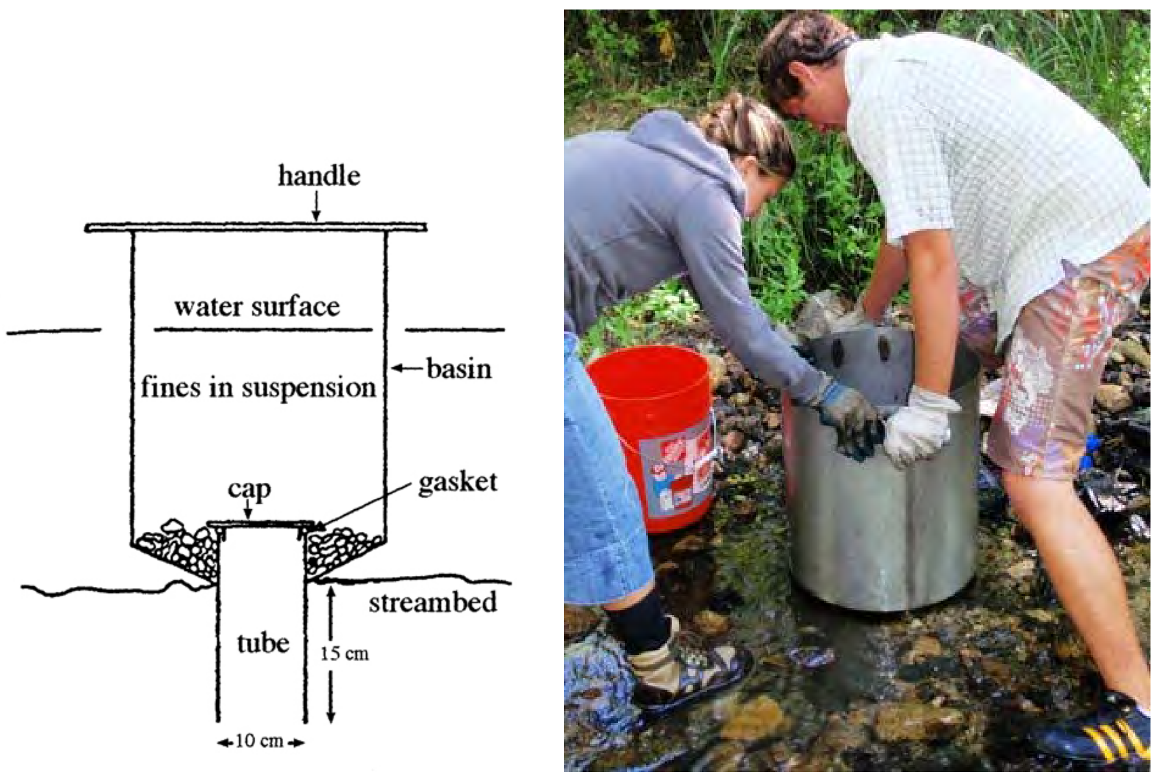

Figure 6. McNeil Core Sampler diagram (left) and the Core sampler in use (right).

Sediment Dynamics

Two methods will be used to assess sediment dynamics, tracer rocks and scour chains. Methods are described below.

Tracer Rocks

Bed mobility, and the frequency and magnitude of sediment transport can be estimated using tracer rocks. Tracer rocks are brightly painted or out-of-basin quartz rocks that can be deployed in the channel and then identified later. Tracer rocks should be placed at, or near, the top of the riffles to accurately assess movement of placed material. Following bankfull or greater flow events, tracer rocks will be monitored to determine if the flow event caused: 1) minor bed surface mobilization, indicative of a flow close to the entrainment threshold for tracer movement (i.e., movement of some tracers, and a high tracer recovery ratio); and 2) more extensive surface mobilization in which nearly all tracers moved significant distances (burial leads to a lower tracer recovery ratio) (Stillwater Sciences 2006). Special care to minimize impact during spawning and incubation periods is always observed. Cores may be removed from the native gravel using a McNeil sampler and the void replaced with painted tracer rocks. Tracer materials should be of similar size composition as the surrounding gravel population. Tracer rock piles and/or cores should be marked with GPS. As scour occurs material is swept downstream. Mobilized tracer rocks are identified using snorkel survey or underwater video camera and their position marked using GPS. Mobilization distances and rates can be determined and extrapolated to account for gravel mobilization of the site; these results will inform sediment budgets, maintenance and injection schedules, and long-term management plans.

Scour Chains

Scour devices (scour chains or scour beads) are mechanisms implanted in streambeds to measure scour and fill of sediment over a period of time (Figure 7). These devices are constructed from lengths of chain, or wire with beads connected to a steel head that is driven vertically into the substrate. During scour and fill events the exposed portion of the scour device lays over to the depth of scour, as flow is reduced sediment buries the scour device. The portion of the chain now parallel to the streambed records the depth of the scour (Figure 8). Scour devices will be placed in transects through the project area and in the control areas. Locations will be recorded with GPS or survey equipment during the topographic/bathymetric surveys. Devices will be monitored on a regular basis typically following flow events or on a seasonal basis.

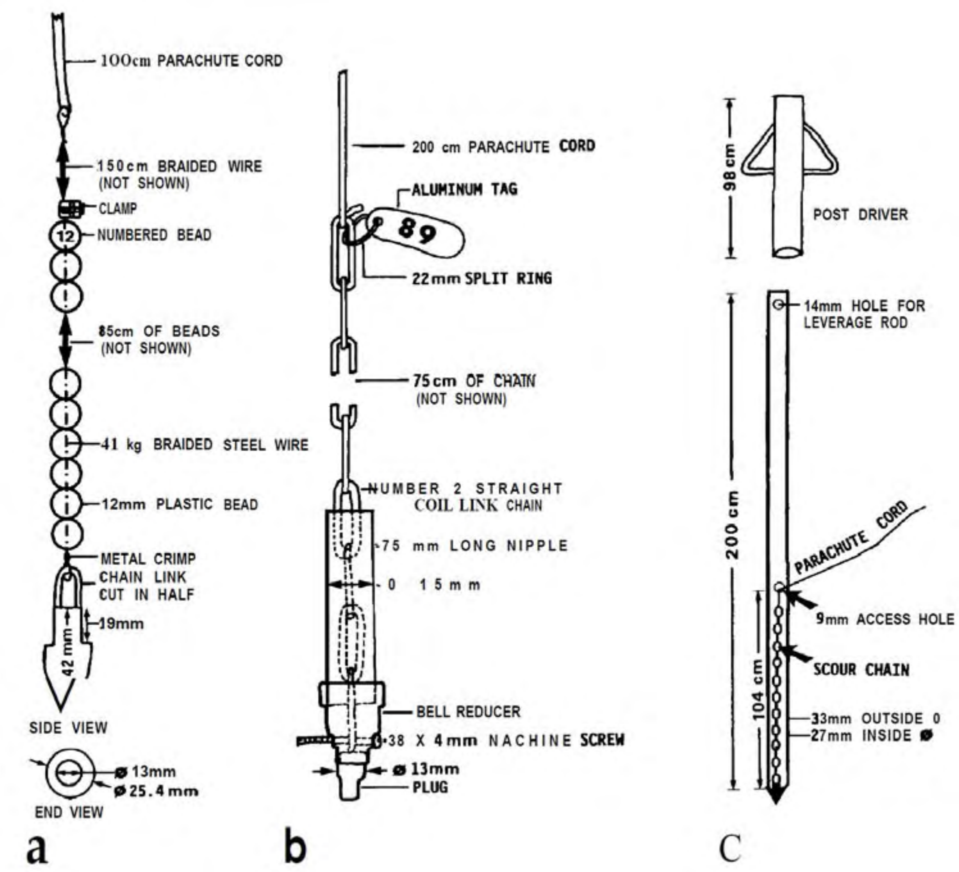

Figure 7. Scour device configurations (Nawa and Frissell 1993).

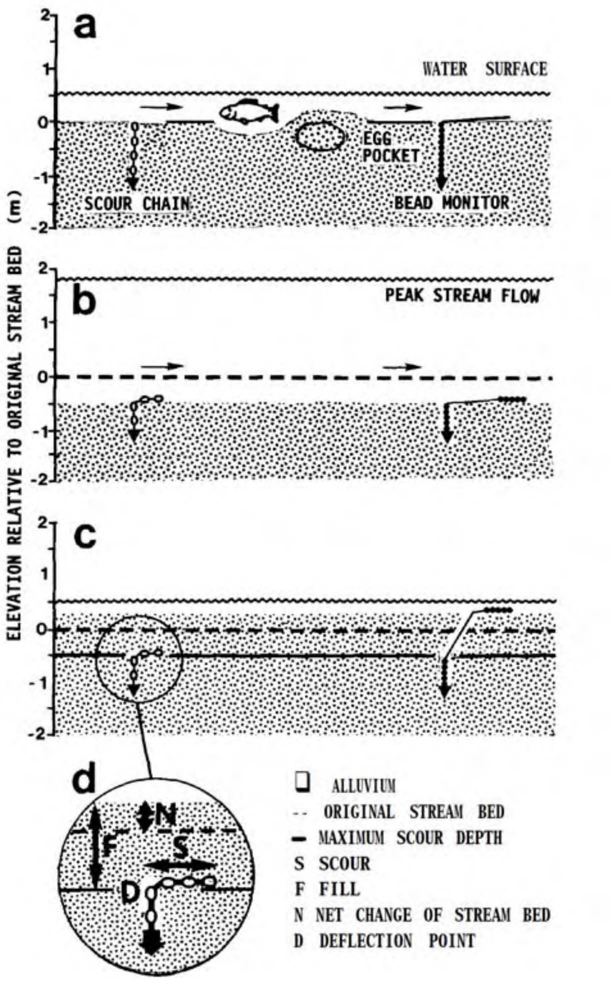

Figure 8. Scour device function (Nawa and Frissell 1993)

Biological Conditions

Repeated field surveys will be conducted to determine if the restoration actions created suitable habitat for target species, and to compare pre- and post-restoration conditions. Surveys of biological conditions will include photo points, vegetation surveys, floodplain soil characteristics, and fish and wildlife surveys.

Photo Points

All photographs will be taken at the same height and in the four cardinal directions (i.e., North, South, East and West) at each sampling site. Photos will be labeled and stored as part of the ArcGIS spatial database developed during monitoring activities. Qualitative conditions can be compared using the photo series and change due to restoration activities can be documented.

Photo points will be established among the sampling sites, and periodic imagery will be collected throughout the project duration for a qualitative measure of habitat structural changes. Each vegetation plot will also have specific photo points associated with them. Monitoring will also include detailed mapping of the extent and geomorphology of side channels, floodplain, and river mainstem. Additionally, outreach coordination with other groups (e.g., Audubon Society) will provide information on use by non-target species (e.g., birds). All information will be spatially explicit (when information is available) and summarized in a spatial database (i.e., ArcGIS).

Vegetation Characteristics

We will use two primary vegetation monitoring methods for all levels of monitoring and to test project hypotheses about the success of natural recruitment following restoration activities. To improve the probability of detecting changes in vegetation patterns due to project implementation, a stratified-random sampling approach will be applied to vegetation data collection. We will place permanent plots at an upstream control site, at the project site and at a downstream impact site, stratified across the floodplain based on current vegetation structure and distance from the active channel modeled flood recurrence interval. Measures of vegetation composition, dominance and structure over time will be correlated with measures of sediment distribution, hydrology and topography to document project effects and suggest causal mechanisms.

Project Area Vegetation Mapping

The delineation and labeling of vegetation within the project area will be utilized for project planning, implementation monitoring and effectiveness monitoring. Because current aerial photographs of the project area are not available, land cover will be mapped using natural color 1 meter resolution Digital Orthophoto Quarter Quad (National Agricultural Imagery Program 2005). Delineations will be done on-screen at 1:3000 scale with a minimum mapping unit of 0.62 acre (0.25 ha) (Vaghti 2003). Pre-project mapping will primarily delineate existing vegetation to assist with the field sampling effort and overall project planning.

To assess whether retained vegetation followed design plans, post-project satellite imagery will be compared to the pre-project land cover delineations and design plans. If imagery is not available then a subset of retained vegetation patches, representing a minimum of 10% of total retained vegetation area, will be randomly selected from the design plan. These patches will be located in the field and their boundaries recorded and compared to the design plans.

To address questions of river shading, vegetation encroachment into the active channel, cover of non-native woody species, and connectivity of woody vegetation across the project area vegetation mapping will be repeated after 2 years. Field collected data will be used to further refine the delineations and map labels.

Field-Collected Vegetation Data

A BACI study design (Eberhardt 1976) will be used to improve the probability of detecting changes in vegetation patterns due to the project restoration actions. See Figure 2 for a simplified schematic of the field sampling design, including an upstream control site and a downstream impact site. Using GIS, the project area will be stratified by existing land cover (see vegetation mapping above), modeled flood recurrence interval (1-5 yr, 5 yr, 10 yr, 100 yr), topographic restoration, and active vegetation restoration then overlaid to produce a series of polygons.. Within each stratification, a subset of polygons will be randomly selected for sampling. The project areas subjected to topographic and active vegetation restoration will be sampled more intensively, both spatially and temporally, than the remainder of the site. Specifically, if the total planted area is less than 12.14 hectares (30 acres) then 2% will be sampled; if the total planted area is greater than 12.14 hectares then 1% will be sampled (Harris et al. 2005).

All sampling sites will be surveyed to provide GPS coordinates, and annual monitoring will occur in the early summer (or peak season for herbaceous flowering plants) will occur. The number of plots will provide adequate sample sizes necessary to provide robust data for statistical tests and comparisons. Plant response in the BACI context will be tracked at a sub-set of sampling locations, and composition, distribution, and recruitment will be assessed with other environmental variables (e.g., groundwater levels, inundation frequency, etc.). A 400 m^2 (20 m x 20 m) sampling plot, the standard for riparian shrub and tree vegetation (CNPS 2007), will be centrally located within each polygon selected for sampling. The following protocol will be applied to the project area, upstream control, and downstream impact sites. All plots will be marked with GPS locations, photographs, and detailed on-the-ground mapping and descriptions. Vegetation and substrate sampling will follow the California Native Plant Society Relevé Protocol (CNPS 2007).

To address questions of recruitment, native and non-native cover and vegetation community organization data listed in Table 7.I, 7.II and 7.III will be collected for all plots following the CNPS relevé protocol.

Table 6. Field collected vegetation data.

DATA TYPE	CLASS	SUBCLASS	EXTENT
I. Vegetation. Complete composition by stratum will be identified and cover visually estimated.	Tree		
	Shrub		
	Herb		
	Seedling		
	Sapling		
	Non-vascular		
II. Surface. The percent cover of each surface will be visually estimated.	Basal area of stems		
	Bedrock		
	Litter		
	Water		
	Soil/rock:		
		Fines	<0.2 cm
		Gravel	0.2-7.5 cm
		Cobble	7.5-25 cm
		Stone	25-60 cm
		Boulder	>60 cm
III. Recruitment. Mapping and diameter of all woody seedlings within subplots.	Species		
	Stem diameter	<1.0 cm	< 1.0 cm
		1.0 -10.0 cm	Actual diameter

Wildlife Surveys

Wildlife surveys will occur with qualified personnel following guidelines outlined by USFWS and CDFG (http://www.dfg.ca.gov/wildlife/nongame/survey_monitor.html). There are survey protocols for specific listed species. Surveyors will sample the project area to look for signs of residence or breeding in the area. Nests of listed species will be flagged and the location recorded; flagging will also establish buffer following recommendations of CDFG.

Fish Surveys

Snorkel Surveys

Snorkel surveys will be conducted to assess juvenile and adult use of the restored sites. Snorkeling methods will be consistent with other studies (Edmundson et al 1968; Hankin and Reeves 1988; McCain 1992; Jackson 1992; Dolloff et al. 1996; Cavallo et al. 2003). Sample units will be snorkeled by two or three divers moving upstream adjacent to each other for margin habitats and downstream for mid-channel habitats. Fish will be observed, identified and counted by size group as divers proceeded up or down the sampling unit. Counts will be compiled for all divers and recorded as a total for each sample unit. Fish will be categorized by species and size classes (0 – 50 mm, 51 – 80 mm, 81 – 100 mm, 101 – 120 mm, 121 – 150 mm, 151 – 200 mm, 201 – 300 mm, and >301 mm). In addition to the above categorizations, additional mesohabitat quality metrics were assessed. Habitat characterizations include qualitative assessments of: river margins; cover habitat; and predominant substrate types.

Survey timing will coincide with rearing, migration and/or spawning timing of the fish species of interest. Stream flow conditions must also be considered prior to conducting a survey for safety precautions. All surveys will be lead by a dive master with training and experience conducting snorkel surveys. Snorkel surveys are most often conducted using teams moving through a survey area in a concerted manner to ensure complete coverage. Generally teams spread laterally across a channel with dispersion based on underwater visibility. Teams should move at the same rate in parallel lanes to prevent double counting fish. Movement most often occurs in the upstream direction to: 1) prevent turbidly from obscuring observations; and, 2) maximize fish observations because fish most often orient facing upstream. To help minimize disturbing fish, surveyors attempt to limit fast or sudden movements and wear mud-brown colored StreamCount drysuits (O.S. Systems, Inc.). Dive slates will be used to record fish species, size categories and other observations.

All surveyors will be proficient in the identification of fish present in the Merced River region (McConnell and Snyder 1972). Daytime surveys generally occur when water temperatures range between 10°C and 18°C. Daytime water visibility is generally the best between late morning and early afternoon, and cloudy or overcast days are preferred over clear sunny days to reduce the effects of shadows on the water. Nighttime surveys are preferred when water temperatures are below 10°C or above 18°C. To gather presence/absence data and baseline habitat use, only a one-pass approach is needed.

River margins will be classified according to position in the channel (i.e., left, middle, or right) and margin type (i.e., bar, bank or main channel). Bar margins are generally shallow with a gradual slope and typically limited vegetation due to scour and regular inundation during high flow events. Bank margins are generally deeper with steep eroding banks and more extensive vegetation; these margins often occur opposite of bar areas against bluffs and levees where high flow induces greater erosion and scour. Main channel areas are away from bars and banks in the middle of the channel where velocities and depths are greater. Cover habitat will be broken down into three qualitative classes (i.e., type, size, and quality). Cover types include instream, overhead, both, or flooded terrestrial and aquatic vegetation and will be further defined by size categories of less than 15 cm, 15 – 30 cm, and greater than 30 cm. Cover quality will be defined as a combination of the percent of surveyed habitat affected by the cover and the degree to which fish depend on the cover. Dominant and sub-dominant substrate types will be defined by organic matter/silt, sand, gravel, cobble, boulder, bedrock, and rip-rap.

Back Pack Electrofishing

Sampling sites may be sampled using standard electrofishing methods. Cramer Fish Sciences uses a Smith-Root, Inc. Model 12B back pack electrofisher (BPS). All BPS operators and crew are trained in BPS operation according to NOAA NMFS Guidelines for Electrofishing Waters Containing Salmonids Listed under the Endangered Species Act (2000). Equipment will be inspected prior to every field use for serviceability to protect fish and ensure safety. Water temperature and conductivity will be measured and recorded prior to every electrofishing survey. No electrofishing will occur when water temperatures reach or exceed 65°F (18.3°C), or when conductivity exceeds 350 μS/cm. Initial BPS settings will be set to NOAA recommended initial settings (100 volts, 500 microseconds pulse width, and a 30 Hertz pulse rate). When needed, settings will be gradually increased to a minimum level necessary to capture fish. Direct current will always be used and settings will never exceed max allowable settings (400 volts, 5 millisecond pulse width, and a 70 Hertz pulse rate). A minimum of one assistant will aid in netting stunned fish and other aquatic vertebrates. Collected fishes will be processed following CFS standard protocol (Gray et al. 2009)

Spawner Surveys

Information on adult spawning will be provided by ongoing CDFG surveys in the Merced River and with additional coordinated surveys by CFS. The CDFG conducts annual escapement surveys in the Merced River, and provides information on abundance and distribution of spawning fall-run Chinook salmon. The CFS team will also conduct redd and spawner surveys in coordination with CDFG. These data will be used to provide for accurate mapping of spawning and redd locations at the sampling sites, and documenting change over time. This information is critical to addressing project hypotheses regarding the productivity of the restored habitat for spawning salmon. Spawner surveys will continue to be conducted during the fall-run Chinook salmon spawning season (mid-October to January) up to every other week. These data (and other information as necessary) will be used to calculate redd densities per riffle in the restored channel and document trends in redd densities over time. Latitude and longitude will be collected for individual Chinook salmon redds, and a total count will be summed for each sample date. Coordinates for individual redds will be used to display the spatial extent of spawning at the site for each sample date.

Determining Diet Composition with Gastric Lavage

Following methods described in Haley (1998) and Koehler et al. (2006), stomach contents of juvenile Chinook salmon will be obtained by gastric lavage. Captured fish will be anesthetized with MS-222 (tricaine methanesulfonate). The fish will be weighed to the nearest 0.01 g and measured to the nearest 1 mm FL. For small fish (>50 mm) a small syringe fitted with a 3-mm diameter rubber tube will be put into the fish's esophagus. The syringe will be used to gently emptied the stomach contents from the fish into a 106 µm sieve, and the fish will be returned to freshwater to recover. The stomach contents are then washed into a Ziploc™ or Whirlpac™ plastic bag and preserved with 70% ethanol. Organisms in the stomach contents will be examined and identified with a light dissecting microscope to the smallest taxonomic resolution reasonable (usually species, but in some cases to the family level). Each prey category will be enumerated and literature weights will be used to estimate volume.

Macroinvertebrates

Macroinvertebrate communities will be monitored to determine the composition and abundance of various species. Invertebrate sampling will occur in replication at each sampling site with samples collected in the spring and summer. Samples will be collected with a 330 mm i.d. X 400 mm high, stainless steel 368 µm nitex Hess Stream Sampler (bottom area opening = 0.086 m^2) with an attached 368 µm dolphin bucket (Figure 9). The Hess sampler design isolates the sample area, hinders contamination from drift and provides consistency in area/volume sampled and invertebrate size. Samples are taken to a depth of approximately 0.5 ft (15 cm) within the substrate. Drift insects will also be collected using a drift sampler with 106 µm mesh pulled for 32.8 ft (10 m) across the water's surface. Collected samples are rinsed into 500 mL labeled bottles with 70-95% ethanol. Samples will be transported to the laboratory and sorted under a light dissecting scope (e.g., 60X). Taxa will be identified to species as possible; size classes and life stage will be recorded. Individual organisms were grouped by type, further categorized by individual size classes (<2, 2 – 7 mm, 8 – 13 mm, 14 – 20 mm, and > 20 mm) and life stages (larva/nymph, pupa and adult), and enumerated for each type-size-life stage combination. Organisms will be grouped into functional feeding categories following Merritt and Cummins (1996), Wiggins (1998), and Pennack (1989).

Figure 9. Biologists using Hess Sampler to collect benthic macroinvertebrates in the Merced River.

Validation Experiments

Egg-to-Fry Survival

The focus of this validation experiment is to measure the survival and growth of Chinook salmon embryos in the restored and unrestored reaches of the MRR. Egg incubation tubes will be buried at the various sampling sites to test survival and growth of fertilized eggs. Egg tubes will be constructed of modified 35-polyvinyl chloride (PVC) with two caps to close the ends (Figure

10). Evenly spaced holes will be drilled in the tubes, and the inner surface covered with 0.14 in (0.35 mm) plastic mesh screen following methods described in Leitritz and Lewis (1980) and Merz et al. (2004). At each site, an artificial redd will be constructed and egg tubes will be buried horizontally and perpendicular to stream flow at these sites. Tubes will be buried to a depth of 0.87 in (22 cm), the approximate depth of redd pockets as reported by Healey (1991) and Montgomery et al. (1999). Tubes will stay in the gravel for 4 – 6 weeks, and all organisms will be recovered and survival and growth will be determined in the field. A one-way *t* test will be used to compare the survival and growth of embryos from the restored and unrestored sites.

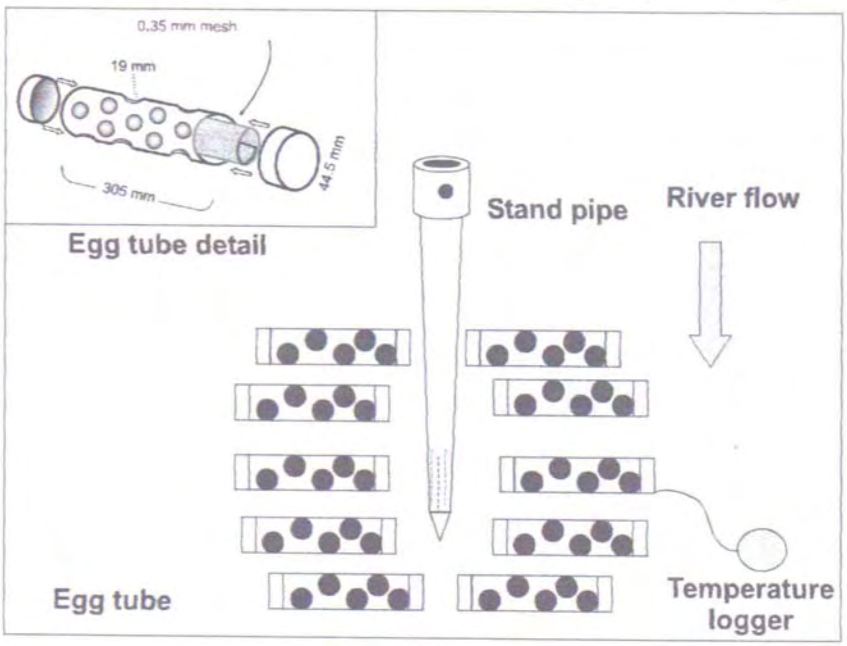

Figure 10. Diagram of egg tube construction and deployment in relation to river flow, temperature logger and permeability measures (from Merz et al. 2004).

Juvenile Growth Potential Model

To investigate the function of juvenile habitat provided as a result of this restoration project, we will evaluate the change in habitat in terms of modeled growth potential for juvenile salmonids.

Alternative Methods for Obtaining Bioenergetics Model Data

The key parameters to run the bioenergetics model are: temperature, consumption rate, diet composition, prey quality, and fish size. Detailed temperature data will be collected as part of the effectiveness monitoring program. Information on prey quality will use established literature values unless funds support laboratory analysis on energy content. Data on consumption rate and diet composition can be obtained with a variety of methods, considering the proper assumptions.

Method 1: Up to four large enclosure nets (i.e., 10 X 20 ft and X 0.25” mesh size) will be established in various restored-reference habitat types (as allowable by river conditions). Up to 100 juvenile Chinook salmon will be held in the enclosure nets for 16-24 hours. Diet contents of fish will be determined from samples (n=10-20) collected every eight hours following standard procedures of gastric lavage (see previous description). After 24 hours, any remaining fish will be sampled for stomach contents. Diet information will then be compiled to determine overall diet composition for that habitat type and time of year.

Method 2: Diet information may also be obtained through the fish surveys at the project and control sites. Beach seining or electrofishing may allow low impact capture of juvenile Chinook salmon that could be sampled for diet contents using gastric lavage. Information on consumption rate will have to be based on stomach fullness. This method assumes the fish have been feeding for the past several hours in the area collected. This method has additional limitations in feasibility due to the very low numbers of wild fish and the inability to collect a suitable sample size.

Method 3: If Methods 1 and 2 are not available, diet information for the local area of the Merced River may be obtained through sampling juvenile Chinook salmon (by gastric lavage) at the RST monitoring operations at Hopeton, CA. A sub-sample of juvenile Chinook salmon (up to 10) could be collected during the out-migration. Diet composition information could be collected for early and late out-migrants. Assumptions would include that the fish collected in the RST operations have diets representative of those feeding in the project reach. [This method would be less suitable for depicting the diets of fish feeding on the restoration floodplain, post-project.]

Information from any of the above methods would be used with the “Wisconsin” computer model (Hanson et al. 1997) to simulate fish growth in response to changes in body mass, diet composition, and temperature. Results obtained from these experiments will provide a *relative* measure of potential growth at the various sites.

Data Analysis and Evaluation

Statistical analyses will be performed with several programs (i.e., S+, R, JMP, Origin, PRIMER, and Excel). Multivariate statistics will be used along with linear and multiple regressions to relate various results to explanatory variables, such as vegetation recruitment success, spawner distribution and abundance, fish use and growth potential to physical conditions. There are a variety of statistical tools available to analyze data from non-replicated BACI studies (Miao et al. 2009). As the sampling framework is finalized, these tools will be researched further and described herein.

FIELD TRIP PLANNING

Permitting

All of the activities in this monitoring program will only occur once all the permissions and permits have been obtained. The property is owned by CDFG and all permissions to obtain property access have been achieved. Control sites exist on property owned by MID and Santa Fe Aggregates. Coordination with these landowners has allowed us to access these sampling sites. All field personnel will have a Scientific Collecting Permit (SCP) with a current amendment letter describing all methods and activities. This document provides additional detailed information on methods and sampling design to CDFG. A federal 4(d) permit is required when working in areas with steelhead which has been renewed for 2010. All safety and fish handling precautions will be followed.

Gear List and Planning

The following supplies and equipment will be needed to complete the described monitoring activities:

Onset U20 Transducer (13)

Solinist Water Level Meter (1)

Disposable Bailer (1)

Stand pipe (2) and Other Supplies

Multi-Parameter YSI 600XLM and accessories (1)

HOBO Water Temp Pro v2 (12)

HOBO Waterproof Shuttle (2)

HOBOWare for Windows (1)

NIST Certified Thermometer (1)

Hach 2100P turbidimeter and accessories (1)

Invertebrate sampling supplies

Fish use survey supplies

Wildlife survey supplies

Ohaus® Scout Pro Electronic Balance, 600g x 0.01g

Ohaus® Adventurer™ Pro Electronic Balance, 51g x 0.001g

Dissecting Scope

Fiber optic lights

Enclosure nets

Egg tube supplies

Sample fish and embryos (if available)

The following provides a draft sampling schedule with objectives (Table 7) and survey frequency, staff and duration and deliverables (Table 8).

Table 7. Field sampling schedule and project timeline.

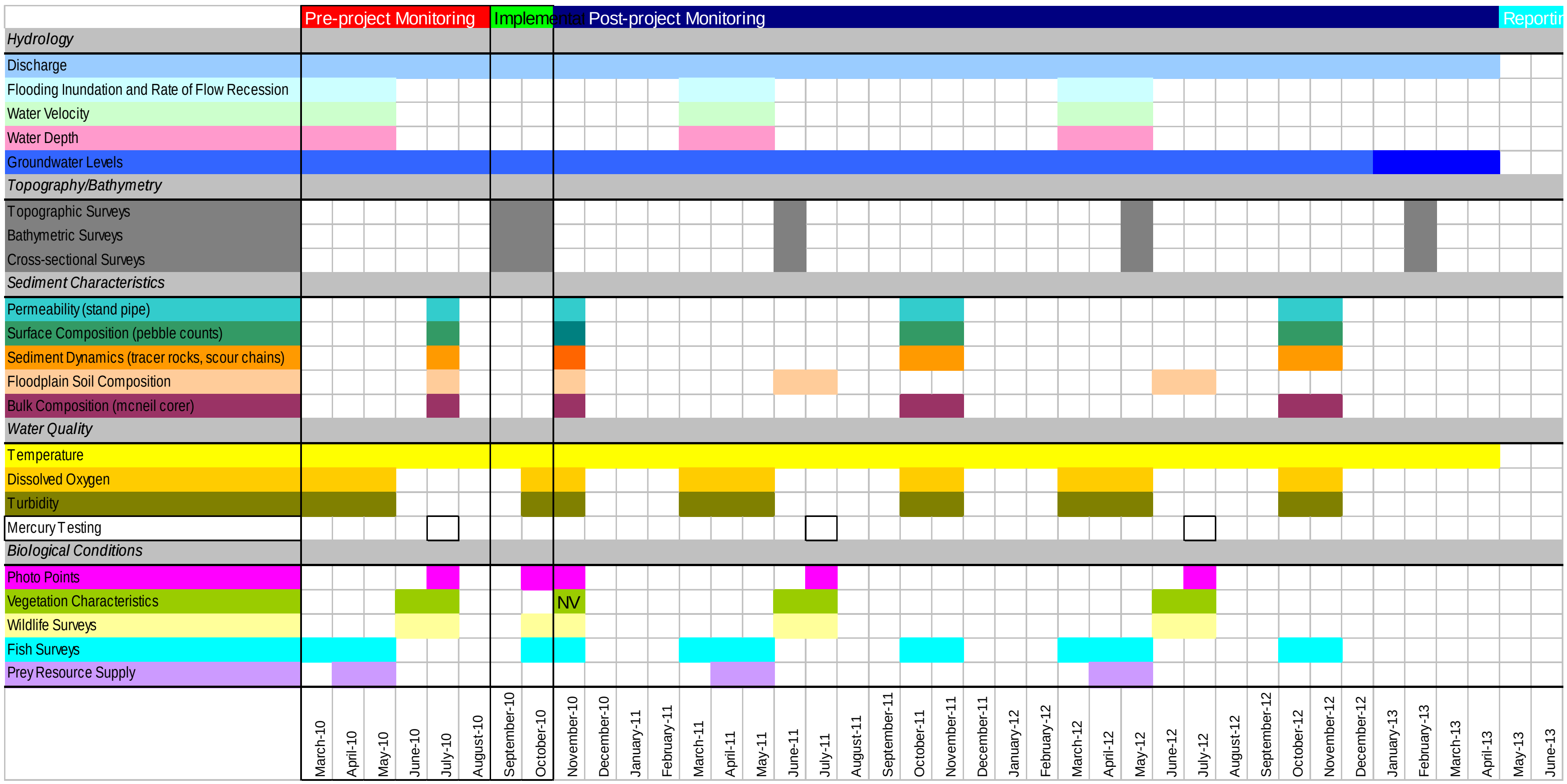

Table 8. MRR summarized monitoring activities and deliverables.

Activity	Survey Frequency	Survey Time and Duration	Personnel	Deliverables
Hydrology	Continuously	Continuously	MID and data loggers	-data -summarized data
Topography/Bathymetry	Annually	3 field days in January	2 Technicians to accompany PWA	-Digital elevation models (dems) -Raw XYZ data
Water Quality, Sediment Characteristics and Dynamics,	Bi-annually	4 field days in Spring/Fall	3 Field Technicians and Biologist	-Data -Summarized data and graphs
Biological Monitoring I: Photo Points, Fish and Wildlife Surveys and Prey Resource Sampling	Bi-annually	4 field days in Spring/Fall	3 Field Technicians and Biologist	-Data -Summarized data and graphs -Voucher specimens (invertebrates/diets)
Biological Monitoring II: Vegetation Surveys	Annually	5 field days in May or June	1 Field Technician and Plant Ecologist	-data -summarized data and graphs -summary report
Enclosure Experiments	Annually	4 field days in the spring (as dictated by flow regime)	3 Field Technicians and Biologist	-data -summarized data and graphs
Egg-to-Fry Survival	Annually	4 field days (2 for placement; 2 for egg tube recovery) in the fall	3 Field Technicians and Biologist	-data -summarized data and graphs
Native Vegetation Recruitment	Annually	5 field days in May or June	1 Field Technician and Plant Ecologist	-data -summarized data and graphs

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